ON THE COVER

NO ONE ever thought a man would some day be able to pursue fish underwater and then kill them with a gun that shoots steel shafts, but there is proof on our cover that the time is here. The picture depicts a wearer of an Aqualung swimming freely under the surface of the sea, breathing air that he carries on his back and towing a specimen of the finny tribe that has fallen prey to a weapon that is fired with compressed gas. More about this remarkable new development will be found farther along in the issue.

IN THIS ISSUE

A TREATY signed in 1950 provides for possibly trebling the production of hydroelectric power at Niagara Falls, with the additional generating facilities to be divided about equally between the United States and Canada. Thus far, we have done virtually nothing towards turning out our share of the kilowatts, because we haven't been able to decide whether some branch of the government or private power companies should do the job. Last month a committee in Congress approved a bill that would authorize private capital to go ahead, but the measure still faces a rocky road before it passes. Meanwhile, as recounted in our leading article, which is the first of two parts, Canada is well advanced on the construction of a new plant that will provide 1,200,000 hp.

•

THE efficiency and economy of modern earth-and-rock excavating equipment is brought into sharp relief by the story of what the DeBardeleben Coal Corporation is accomplishing in Alabama. To mine a 2-foot layer of coal, it is removing 40 feet of overburden, mostly rock. The secret of its success is the size of the operation. A Quarrymaster drill puts down 80 to 100 feet of large-diameter blast hole per hour, and the broken material is cast off the coal seam by one dragline at a rate of 10,000 cubic yards a day. It's a big job, being done in a big way. Page 218.

•

A DIVER need no longer be encumbered with a stiff lead-weighted suit and long hose lines to bring him breathing air from the surface. A new device, the Aqualung, lets him carry his air supply under high pressure and permits him to frolic like a fish. A smooth-working regulating valve feeds air to him in accordance with the demands of his lungs. Page 221.

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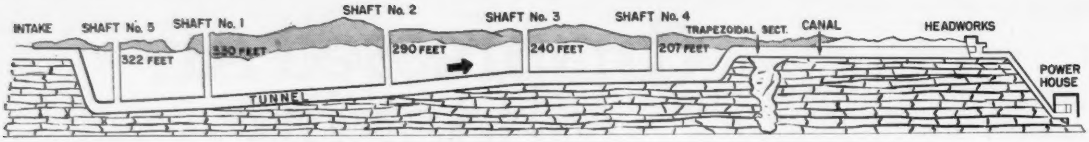
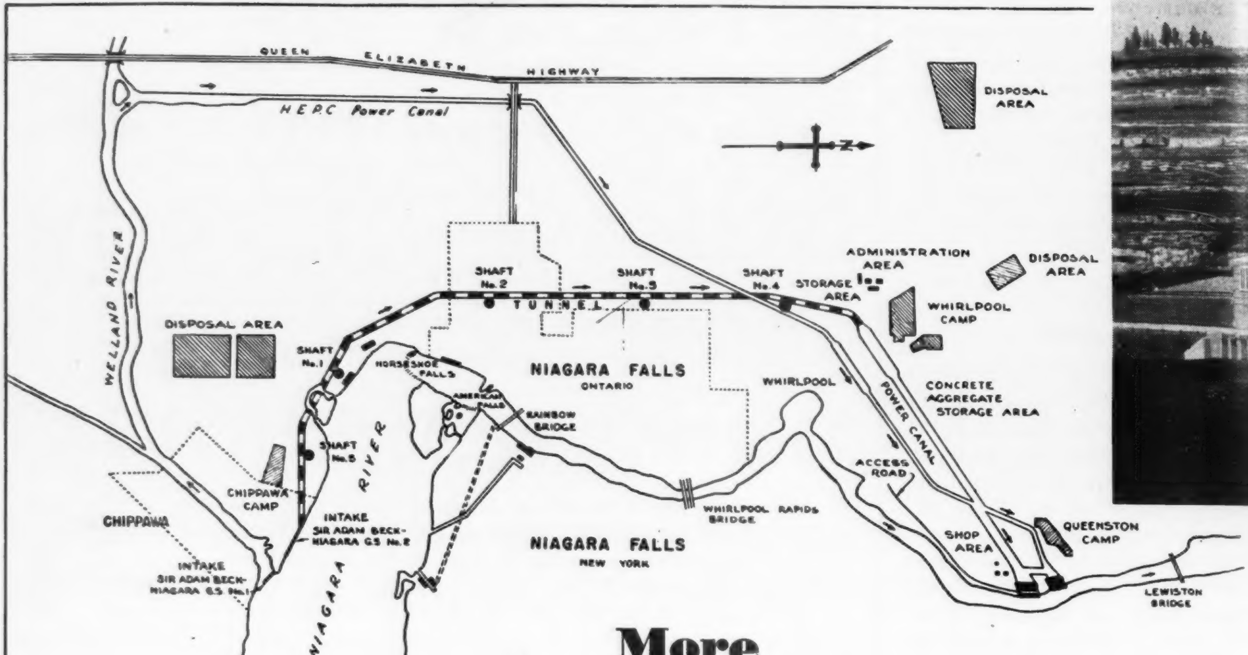




More Canadian Kilowatts at Niagara

PLAN AND PROFILE

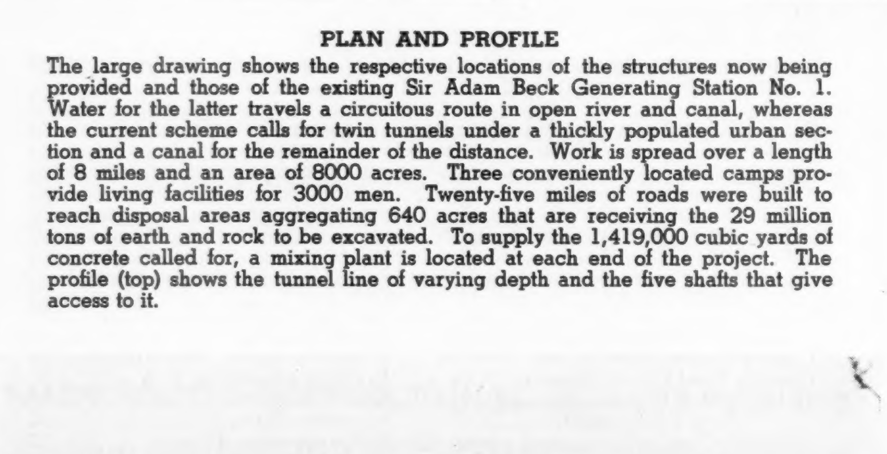
The large drawing shows the respective locations of the structures now being provided and those of the existing Sir Adam Beck Generating Station No. 1. Water for the latter travels a circuitous route in open river and canal, whereas the current scheme calls for twin tunnels under a thickly populated urban section and a canal for the remainder of the distance. Work is spread over a length of 8 miles and an area of 8000 acres. Three conveniently located camps provide living facilities for 3000 men. Twenty-five miles of roads were built to reach disposal areas aggregating 640 acres that are receiving the 29 million tons of earth and rock to be excavated. To supply the 1,419,000 cubic yards of concrete called for, a mixing plant is located at each end of the project. The profile (top) shows the tunnel line of varying depth and the five shafts that give access to it.

Work is Well Advanced on New 1,200,000-hp Generating Plant Below the Falls

H. R. Rice

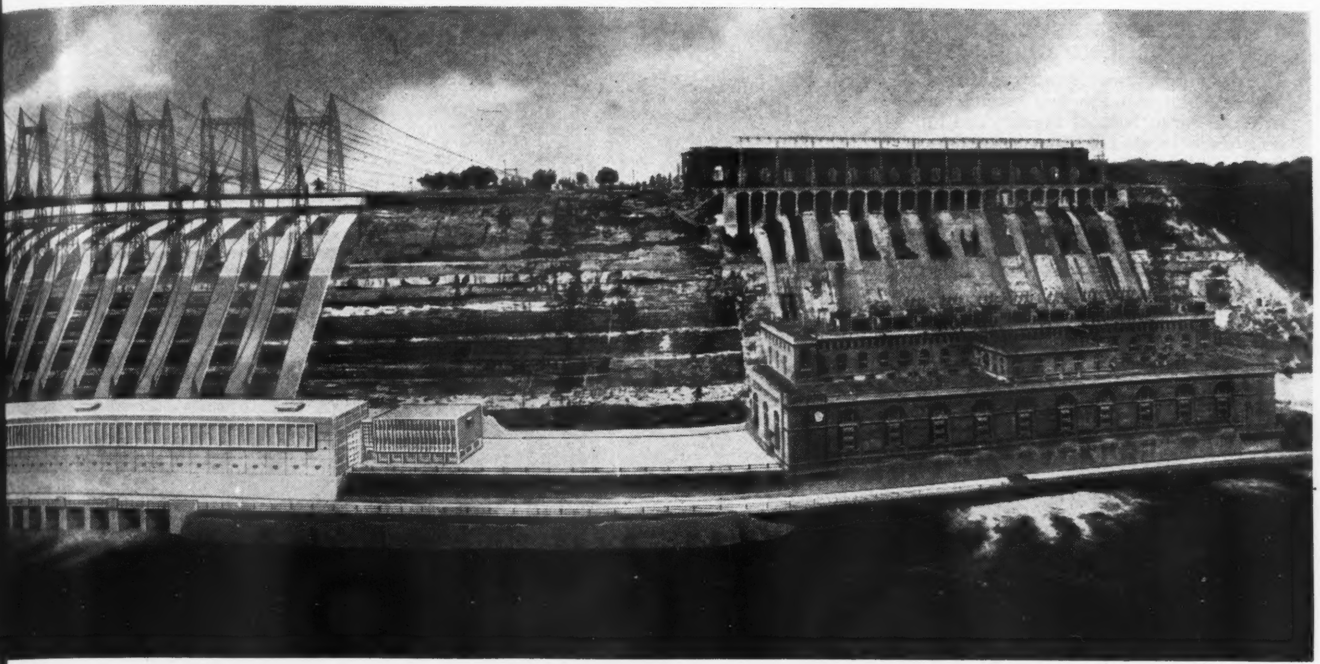
Part 1

MENTION of Niagara Falls immediately conjures up a vision of the most spectacular tourist attraction on this continent in terms of the number of people who go there each year to view the spectacle and to round out their visits in the many short tours to other scenes along this mighty waterway, all of which provide aesthetic delight to millions. Less well appreciated, at least by the general public in the United States, and for rather valid reasons, is the great economic import to both the States and Canada of the power of Niagara's



TAKING FORM

Crowding its way into the rather limited space, No. 2 station is gradually taking shape just upstream from its 31-year-old neighbor. High on the cliff may be seen the black circular openings from which water will emerge to enter the penstocks. The powerhouse will be 63 feet wide, 60 feet high and 931 feet long when all twelve of its 500-ton generators are in place.



THE NEW LOOK

On a photograph of the existing powerhouse, right, an artist has drawn the new and larger neighboring structure as it will appear when completed. Sir Adam Beck, for whom both stations are named and who is called the father of Ontario's Hydro-Electric Power Commission, was once ridiculed for predicting that the Niagara River would some day yield a million horsepower of energy. These two plants alone will have a combined installed capacity of 1,725,000 hp.

waters flowing at a rate of about 200,000 cubic feet per second and dropping some 326 feet in their 35-mile passage from Lake Erie to Lake Ontario. The energy expended in this descent amounts to nearly 8,000,000 hp, a fact that has intrigued the minds of progressive men in both countries for two centuries.

It was not until the latter part of the nineteenth century, however, that development at Niagara could be seriously considered. For it was then that the well-known controversy between Thomas A. Edison and George Westinghouse as to the relative merits of direct-current and alternating-current generation came to an end and it was resolved to everyone's satisfaction that it was more economical to use alternating-current equipment and to transmit the energy to distant points of consumption.

The topographic and geological features of the Niagara River are such that any attempt to harness even some of its power entails engineering works of considerable magnitude, and they preclude any scheme involving purely mechanical transmission. The capital outlays necessary for the construction of plants to produce electricity for local use in the relatively limited industrial establishments in the immediate vicinity at the turn of the century were prohibitive, and it was apparent that any development would have to be undertaken with the idea of serving larger areas and distant centers of population and industry.

Indeed, the first generating station to take advantage of some of the difference in elevation between Lakes Erie and Ontario was built at DeCew Falls on Twelve-Mile Creek, so named because it is that far west of the Niagara River. There, in 1897, one of the first Canadian "high-head" hydroelectric plants was put into operation. In recent years this installation was augmented by a new powerhouse, bringing the peak capacity at this site to about 201,000 hp.

The history of the DeCew Falls station goes back to the days when one John de Cou, a man of Huguenot French descent who made his way to Canada with other United Empire loyalists in the years following the American Revolutionary War, acquired a number of lots along Beaver Dam Creek. That was in 1788. After serving in the War of 1812-14 he became interested in obtaining more water for mills he had constructed along Beaver Dam and Twelve Mile Creek. The plan he had in mind involved diverting water by a canal system from the Welland River to the creek, and even though it was not carried out in his lifetime or for its original purpose, it did stimulate thought about the original Welland Ship Canal—the first of a series of waterways of which the most modern one is among the world's busiest arteries of commerce.

The 1897 DeCew Falls plant followed by less than 25 years the first experimental dynamo, the electric motor, and the incandescent lamp and paved the way for the creation of a string of powerhouses on the Canadian side of the Niagara River that is reaching its culmination in the Sir Adam Beck Generating Station No. 2, certain structural features of which are the subject matter of this series of articles.

The first powerhouse at Niagara was erected on the Canadian side by the old Electrical Development Company whose "Toronto" station was placed in service in 1906 and utilized but 137 feet of the head available at the Falls and Upper Rapids. Other private interests who built plants on the Canadian shore during the first decade of the century included the Canadian Niagara and the Ontario Power companies, and only the one operated by the last concern utilizes 180 feet of the estimated 217-foot head at the Horseshoe Falls and Upper Rap-

Highlights of Scheme

Name: Sir Adam Beck-Niagara Generating Station No. 2.

Operating plan: Water taken from the river above the Falls will be conveyed through tunnels and a canal to a powerhouse 6 miles downstream from the Falls.

Generating equipment: Twelve units with an installed capacity of 900,000 kw (1,200,000 hp) to be placed in three stages of construction: five units scheduled for operation in 1954, six in 1955, the remaining one in 1956.

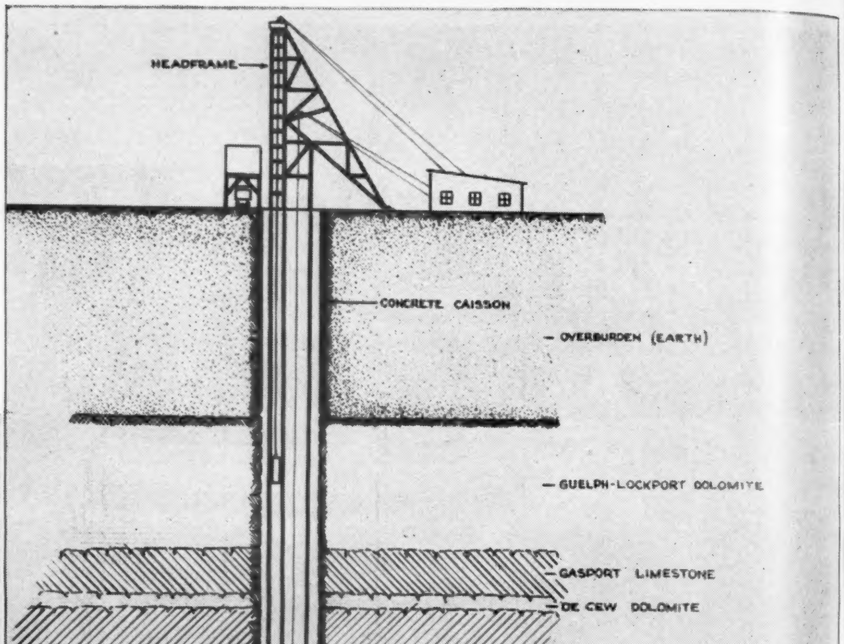
Engineering features: Tunnels are largest (51 feet as excavated) of their length (5½ miles) ever driven. Canal will be wider and deeper than Suez. When in full operation, the power plant will utilize 15,000,000 gpm of water.

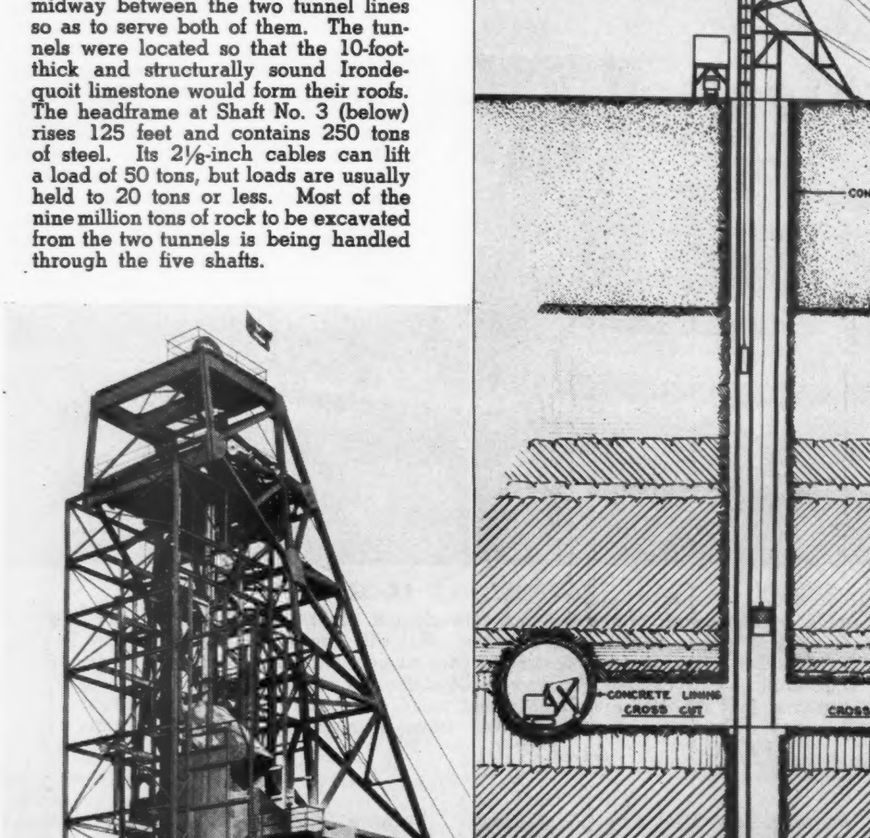
Sponsor: The Hydro-Electric Power Commission of Ontario.

Cost: More than $300,000,000.

ACCESS SHAFT AND UNDERGROUND GEOLOGY

The drawing shows a typical shaft, sunk midway between the two tunnel lines so as to serve both of them. The tunnels were located so that the 10-foot-thick and structurally sound Irondequoit limestone would form their roofs. The headframe at Shaft No. 3 (below) rises 125 feet and contains 250 tons of steel. Its 2⅛-inch cables can lift a load of 50 tons, but loads are usually held to 20 tons or less. Most of the nine million tons of rock to be excavated from the two tunnels is being handled through the five shafts.





ids. In the order named, and with additions made over the years, the capacities of these powerhouses are: 145,000 hp, 108,000 hp, and 181,000 hp.

Contemporary construction on the American side consists of the Schoellkopf and Adams stations which, with enlargements and alterations, are rated at 483,000 hp and 107,000 hp, respectively. They were built with private capital by the old Niagara Falls Power Company and have been owned and operated by it and its various successors, the Niagara-Hudson and the present Niagara-Mohawk Company.

In 1922 the Hydro-Electric Power Commission of Ontario put into use the plant at Queenston, known as the Sir Adam Beck Generating Station No. 1, which now has an installed capacity of 525,000 hp and operates under a normal gross head of 315 feet obtained from the natural fall of 370 feet between the top of the Upper Rapids and the lower end of the Whirlpool Rapids.

At the present time, the combined capacities of the plants on the Canadian and American shores of the Niagara River, including DeCew Falls, are 1,194,000 hp and 590,000 hp, respectively, making a total of 1,784,000 hp. However, the great disparity between the two will be reduced once the Americans decide whether New York State, the United States Government, or private utilities shall undertake further development of the power potential of both the Niagara and the St. Lawrence rivers. A bill authorizing the latter to build stations there is now before Congress.

Canadians have traditionally been, and of course still are, very conscious of the value of water power, and at the end of 1952 the Dominion's hydro installations amounted to 14,305,880 hp, or 991 hp per thousand of her population (1951 census, 14,009,429). For purposes of comparison, it is a matter of record (*Mineral Resources of the World* published in 1952 by Prentice-Hall) that in 1948 Canada and the United States produced 87 billion and 50 billion kwh of hydroelectric energy, respectively. Assuming that the United States has 150 million inhabitants, the pér capita figures are in the ratio of 6.5 to 1. With several major projects now under construction in the Dominion, even this high ratio will undoubtedly be measurably increased in the next few years.

Canada is hydro-conscious because suitable water-power sites are well distributed throughout the Dominion and also because present centers of population are far from economic sources of other forms of energy such as coal and other fuels. A good idea of the hydroelectric power available in the Dominion can be obtained from a recent report of the Department of Resources and Development, Ottawa, Ont., (Bulletin 2372, *Water-Power Resources of Canada*), which indicates that the country's presently recorded resources would permit the generation of nearly 66 million hp. Thus

today's installed capacity represents only 22 percent of the total potential.

Sir Adam Beck Generating Station No. 2 is being financed by the Hydro-Electric Power Commission of Ontario, popularly known as Ontario-Hydro, a coöperative and publicly owned enterprise. The vigor and acumen of the Commission loom large in that 42 percent of the potential water-power resources of Ontario has been developed, as compared with 22 percent for the Dominion as a whole. And when the 1,200,000 hp of the present undertaking is put on the line the difference will be much greater.

Ontario-Hydro was formed in 1903 under provincial authority to investigate the distribution of power then produced almost entirely by private companies in the Niagara area. Coincidentally, with the completion of the deliberations in 1906, the Ontario Provincial Government, prompted largely by the advocacy of Sir Adam Beck and others, created the Hydro-Electric Power Commission of Ontario by an act of legislature. Sir Adam was appointed chairman and continued in that office until his death in 1925. His successors were The Hon. Charles A. Magrath, The Hon. Robert Cooke, Thomas Stewart Lyon, Dr. T. H. Hogg, and Robert H. Saunders, the present chairman.

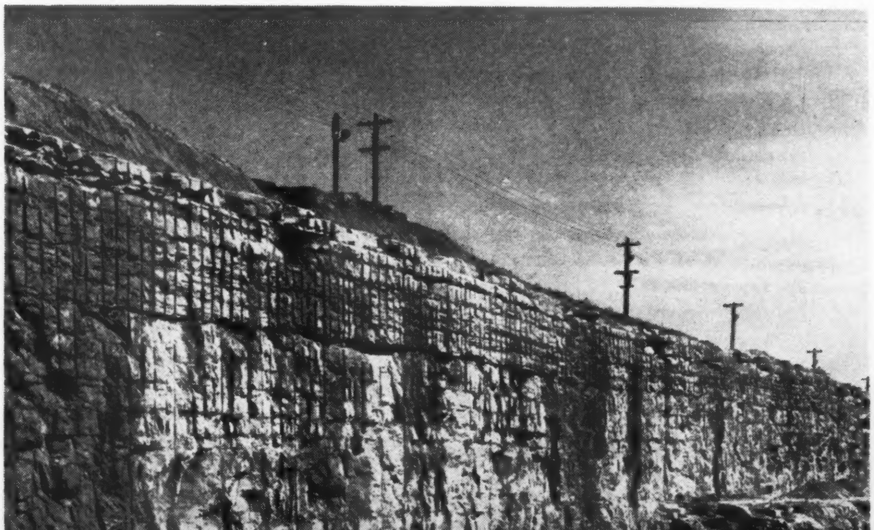
At the start, the Commission was merely a distributor of energy bought from privately owned power plants in the Niagara district. But as its financial structure grew, it was able to undertake minor generating projects and acquire larger stations from private utilities. In 1917 the Ontario Power Company plant was purchased outright, and in 1922 that of the Toronto Niagara Power Company. Parallel developments took place throughout the province in the course of the years until Ontario-Hydro has become preëminent in the related fields of construction, operation, transmission and distribution.

Including energy bought under contract and sent out over its system, Ontario-Hydro's dependable peak capacity amounted to 2,597,200 hp in 1945, and six years later it reached 3,943,400 hp. By the end of 1956, with additions from both hydro and thermal stations now building, it will, it is estimated, approximate 5,807,600 hp, representing an increase of 124 percent in eleven years.

The founding and growth of Ontario-Hydro have been attended by a considerable amount of soul-searching in the province as to the merits of public versus private owernship. Canadians have a healthy appreciation of the tremendous amount of work to be done in the development of their big and promising land, and therefore are not too prone to seek bogeys in every mention of public ownership (at least where public utilities and certain other kindred services are concerned) so long as someone gets on with the job that needs to be done. On this count, Ontario-Hydro has justified itself and has shown exemplary initiative in anticipating and meeting the power demands of Ontario's 4,766,000 people and their industries. Incidentally, in its many ramifications, the Commission is one of the largest single employers of engineers in the Dominion.

Almost as soon as the Niagara's resources began to be harnessed about the turn of the century, it became apparent that agreements would have to be reached between the United States and Canada in order to preserve the spectacular beauty of the cataracts and to apportion fairly the water diverted for power generation. Over the years, the negotiations that have resulted in a succession of treaties have always been characterized by that spirit of friendly coöperation, understanding and mutual respect that obtains between the two countries and stands as a model for the world.

Under the Treaty of 1910, the maximum allotments were: Canada, 36,000 cfs; the United States, 20,000 cfs. The apparent discrepancy was due to the presence on the Canadian side of the American-owned Canadian Niagara Power Company which was producing current for consumption in the United States. During the Second World War emergency agreements were entered into by the two nations, raising the respective



CANAL WALL

The sheer rock face of one wall of the canal that will carry water 2¼ miles from the downstream ends of the tunnels to the powerhouse forebay. Note the drill marks showing near the top. Most of the canal will be of rectangular section, averaging 185 feet wide and 70 feet deep. It will be unlined, studies having convinced the engineers that the friction of the rock will not appreciably affect the flow.

quantities to 54,000 cfs and 32,500 cfs to meet the needs of vital defense plants on both sides of the International Boundary. Again, the reason for the disparity was as before.

The latest of the Niagara Diversion Treaties, that of 1950, was written first to protect the scenic beauty of the falls and gorge and then to permit using the maximum available water for power generation. Between the hours of 8 a.m. and 10 p.m. from April 1 to September 15 a minimum of 100,000 cfs must flow over the cliffs. This period is shortened by two hours from September 16 to October 31. All water in excess of that volume can be utilized for the development of electric energy. But during the nontourist season from November 1 to March 31 any flow exceeding 50,000 cfs can be used for that purpose except when it is necessary to flush ice out of the gorge below the falls. Under the treaty, half of the diversion will be available in Canada and half in the United States. The Dominion is allowed an additional 5000 cfs that the Commission diverts from the Hudson Bay drainage area.

The 1950 Treaty also stipulates that remedial works shall be constructed in the river above the falls to effect a more even distribution of the flow along the crest lines of the two cataracts. Not only will that requirement be satisfied upon completion of the job but erosion at the center of the Horseshoe Falls, now estimated at 2.3 feet per year, will be considerably reduced and many generations thus added to the life of the spectacle.

As soon as the 1950 Treaty was signed, Ontario-Hydro, hard-pressed by the demands of the province's rapidly expanding industry and rural electrification, made arrangements for an immediate start on the $300 million project that will result in placing on the line Sir Adam Beck Generating Station No. 2. Incidentally, the latter will be the fourteenth new power source provided by the Commission since 1945. It will ultimately contain twelve units of 100,000 hp each and bring the aggregate capacity of the stations on the Canadian side of the Niagara River to about 2,000,000 hp, allowing for an eventual reduction in output of the "Ontario" and "Toronto" powerhouses.

Work on the project was begun in January, 1951, and shaft sinking for excavating two parallel tunnels was undertaken the following July. No. 1 Tunnel was started in May, 1952, and is scheduled for completion in December of this year. Originally it was intended to finish the first tunnel before proceeding with the second one. But early in 1952 the Commission decided to begin its construction without delay and, as a consequence, No. 2 Tunnel will be completed a few months after the first one.

At normal water level, the greater part of the total drop of 326 feet in the 35 miles of the Niagara River system is concentrated in the 7-mile stretch from the head of the Upper Rapids to the Queenston end of the Whirlpool Rapids. The older plants, except that of the Ontario Power Company, were designed to utilize only the approximate head available at the Horseshoe Falls—its 162-foot cataract representing about half of the total drop throughout the system.

The success of the Sir Adam Beck Generating Station No. 1 has had much to do with the general concept of the present project, and a few notes on its creation and operation are therefore in order. Ontario-Hydro's first major undertaking in the field of power-plant construction, it was begun during World War I and placed in service in 1922. Together with certain additions made between 1922 and 1930, it has an installed capacity of 525,000 hp and is still one of the world's most efficient hydroelectric stations. At the time it was built it was also the largest. Together with its attendant works it was designed and constructed by the then young Commission's own staff of engineers, and this fact alone is indicative of the character of Ontario-Hydro and its achievements. As previously mentioned, the plant operates under a gross head of 315 feet between the intake at the mouth of the old Welland River to its site near Queenston, and is the first one to take advantage of the combined drop of the river's three principal sections. The desirability of this is proved by the fact that the station's generation factor is 22 kw/cfs,

PARTLY FINISHED TUNNEL

The tunnels are the largest of their length ever driven. They are being excavated 51 feet in diameter and will be lined with concrete 3 feet thick. This picture shows steel arch supports in place and curbs that bear rails for use of the drilling and concreting carriages. The finished section will be circular.

whereas that of the old "Toronto" plant is only 7 kw/cfs.

Water for Station No. 1 is taken from the Niagara River at Chippawa, and is conducted along the Commission's power canal shown on the accompanying general plan. The first 4¼ miles of the system was made by dredging and cutting the banks of the Welland River to a depth of 38 feet, with top and bottom widths of 307 feet and 185 feet, respectively. This stretch extends to a point about a mile north of Montrose, whence the water flows to the plant through an artificial canal cut in overburden and rock for a distance of 7½ miles. This section is 48 feet wide and in places as much as 75 feet deep. At the time of its construction, the canal, together with attendant works, represented an engineering feat of major proportions, involving as it did the excavation of 29,250,000 cubic yards of earth, 4,350,000 cubic yards of rock and the placing of 340,000 cubic yards of concrete.

With the high generation factor of the Chippawa-Queenston stretch, there was virtually no question as to the waterway system for No. 2 Station, though the selection of the route and means was not so simple as in the days of World War I when the first Queenston plant was planned. During the intervening years the land traversed by the Chippawa-Queenston canal has become highly developed and is now urban and suburban in character, in marked contrast to its predominantly agricultural nature 40 years ago. After considering various schemes, the present arrangement of tunnels and canal to deliver 40,000 cfs was decided upon, and its adoption has entailed hardly any appropriation of highly developed land.

The intake site is situated about ¼ mile downstream from the Village of Chippawa, and the works there will consist of two submerged gathering tubes running parallel and 250 feet apart. Each will be about 500 feet long and will have an internal diameter approximately equal to that of a tunnel it will supply with water. The latter will enter the tubes through a series of slots located at intervals throughout their length. This type of intake was chosen primarily because tests showed it to be comparatively free of any tendency to admit floating ice, large floes of which pass from Lake Erie into and down the river system during the winter months. The installation also includes gates so that the tunnels may be isolated and unwatered for inspection and repair. This phase of the undertaking is being executed by Ontario-Hydro's own staff of project engineers which has gained considerable experience as well as an enviable reputation in this class of construction.

From the intake works or gathering tubes, the water will be conveyed through the tunnels for a distance of 5½ miles to emerge at a point just beyond the northern limits of the City of Niagara Falls, Canada. Each of these paralleling conduits, which are being driven 250 feet apart, is being excavated to a diameter of 51 feet and will have a finished inside diameter of 45 feet when the smooth concrete lining is in place. They are being advanced from five shafts spaced at intervals of 6225 feet, more or less, and situated halfway between the tunnel center lines so that both bores may be driven from a single set of shafts.

Tunnel No. 1, following the outer course around the bend of the Niagara River, will be 28,535 feet long and No. 2 27,300 feet, making a total of 55,835 feet or 10.6 miles. Their combined length will therefore be greater than that of any other bore of comparable diameter ever excavated, and represents an engineering job of major proportions. Allowing for reasonable overbreak, they entail the removal and disposal of some 4,000,000 cubic yards of rock, measured in place, and the lining will call for around a million cubic yards of concrete.

By way of contrast, the four diversion tunnels at Hoover Dam have an excavated diameter of 56 feet, but their aggregate length is only 16,000 feet. The Delaware Aqueduct in New York State is 85 miles long, but its greatest excavated diameter is 19 feet and it thus ranks favorably only in terms of earth and rock removal. Other important tunnels with which comparisons may be made are: Fort Peck in Montana, 25 by 25,294 feet; Tahtsa-Kemano, British Columbia, 25 feet by 10.1 miles; and

SLOTS FOR PENSTOCKS

Two of the twelve trenches for housing the penstocks through which water will drop approximately 295 feet to the turbines. Each 500-ton, steel conduit will be 19 feet in diameter, 492 feet long and will descend the cliff on an angle of 60 degrees.

Donje, Norway, 36 by 41 feet (horseshoe section) by 15,310 feet.

It will be noted from the accompanying plan and section that the deepest part of the twin bores is in the vicinity of Shaft 5 near the intake where the invert elevation is some 330 feet below surface level and that the shallowest is at Shaft 4 close to the discharge end where that elevation is about 200 feet underground. This variation is due to the underground geology of the area, and will be discussed more fully later. The intake and discharge ends are in the form of raises inclined 30° from the horizontal, and transition from the tunnel invert grade is accomplished through a vertical circle with a minimum radius of 225 feet. The same radius applies to horizontal curves wherever they occur.

As already indicated, tunnel driving is divided into five sections: Sections 1 and 2 in both bores are being excavated on a unit-price basis under contract with Rayner-Atlas Company, Ltd., a partnership set up for the duration of the project by two Canadian construction firms—George Rayner Construction Company, Toronto, and Atlas Construction Company, of Montreal. Contracts for sections 3, 4 and 5 were awarded to Perini-Walsh & Associates, similarly formed by B. Perini & Sons, Framingham, Mass., U.S.A.; Walsh Construction Company, New York; and Canadian-American Contractors. Sections 1 and 2 comprise 12,435 feet in Tunnel No. 1 and 12,080 feet in Tunnel No. 2; the corresponding combined footages in Sections 3, 4 and 5 are 16,100 and 15,220, respectively.

From the tunnels the water will flow into a canal 12,000 feet long and 185-200 feet wide (185 feet throughout most of its length). The average depth of the excavated cut will be 70 feet, of which 50 feet will be in rock, and the depth of the water carried will normally be around 28 feet. For a distance of 2200 feet from the tunnel outlets, the canal will be of trapezoidal section 500 feet wide at the top and 100 feet at the bottom to provide a channel across the buried St. David Gorge—an inter-Pleistocene course of the Niagara River. Throughout its perimeter, the trapezoid will be paved with concrete laid on a smooth-graded bed of riprap and crushed stone. The canal section entails the removal of more than 16,000,000 tons of earth and rock.

One of the interesting features of the open-cut design is a crossing at the point where it intersects an old canal some 16,000 feet downstream from the tunnel exit portals. Both are high-velocity streams and are at identical water and invert levels. The problem was how to make the crossing without undue loss of head through turbulence. In order to determine how best to meet this unique condition, a series of investigations was carried out with a working scale model of the two waterways and proved that a satisfactory interchange of waters between the two streams, with full maintenance of hydraulic characteristics, could be effected by offsetting the new canal some 45 feet at the downstream side of the intersection. This will cause some of the waters from the old channel to flow into the new one and vice versa.

A model was also put to profitable use in designing the forebay in that it showed that there would be two substantial dead spots of water in that basin if the preliminary plans on paper were followed. It has thus avoided removing some 250,000 cubic yards of rock. It has been estimated that the fairly extensive model studies made in working out details of several phases of the project have resulted in a saving of about $5,000,000.

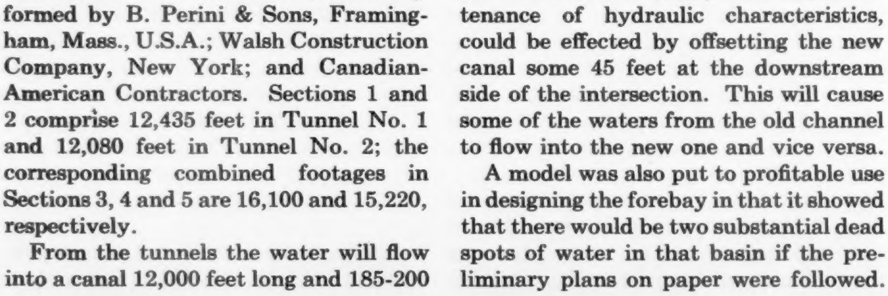
The new powerhouse will be a steel-and-concrete building at the bottom of a 300-foot cliff and situated immediately upstream from Sir Adam Beck Generating Station No. 1. The structure will be 931 feet long, 63 feet wide and 60 feet high, and of the generating units five are scheduled to be put in service in 1954, six in 1955 and the remaining one in 1956. Each will have a capacity of 75,000 kw and its turbine will be supplied with water from the forebay through its own concrete-encased steel penstock 19 feet in finished inside diameter and laid in a slot excavated in the face of the hillside. After delivering its energy, the water will be discharged into the Niagara River at the foot of the Whirlpool Rapids and resume its course to Lake Ontario.

To erect the power plant it was necessary to cut a road down the flank of the cliff, a job that in itself was something of an engineering achievement. It has a length of 1¼ miles and was constructed at a cost of $600,000. With the exception of the tunnels, all excavating and erection, including the intake works, power canal and station, are being done by Ontario-Hydro.

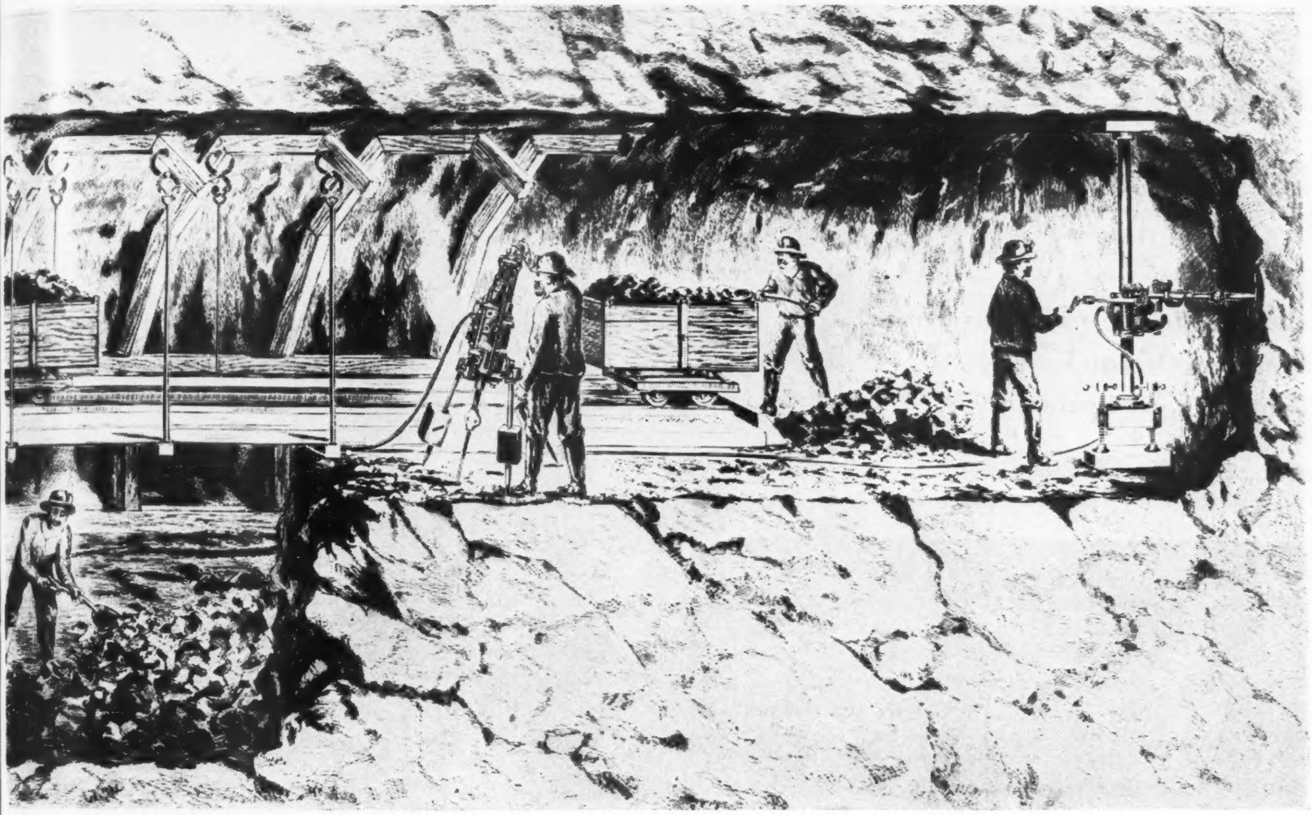
It is of interest to note that the unit cost of excavating on the undertaking as a whole is slightly lower than it was during the latter part of the work on No. 1 plant and shortly after World War I despite the fact that the hourly rate paid labor has increased greatly since then. This is of course attributable to the many improvements made in the past 30 years or so in the design and manufacture of equipment, in explosives and in engineering organization.

Spoil disposal presented a considerable problem, particularly in view of the built-up condition of the City of Niagara Falls and the Township of Stamford. By careful planning it was possible to provide for the purpose a total of about 640 acres situated at various strategic points. To reach these, some 25 miles of heavy-duty construction roads had to be built. Upon completion of the project, the dumps are to be suitably landscaped at Ontario-Hydro cost and all temporary buildings and structures are to be removed.

To avoid placing undue strain on existing municipal services, a great deal of planning had to be done to establish camps and other facilities to meet the needs of a temporary additional population of 7000. Included among these are a self-contained 30-bed hospital, water-distribution systems, sewage-disposal plants and the Commission's own security organization. On the engineering side, Ontario-Hydro has set up two large con-



COMING UP FOR AIR
The downstream end of No. 1 Tunnel where it slopes upward to meet the bed of the connecting canal.



EARLY NIAGARA TUNNEL

Tunnels are not new to Niagara, but the equipment and methods utilized in driving them have changed greatly since 1890 when a 7250-foot bore was excavated, as shown in this old print. Twenty-five Rand piston-type rock drills were used. Note the hanging platform that permitted advancing the top heading and bench simultaneously.

crete mixing plants: one near Shaft 5 and the other, larger one close to the source of supply of aggregate obtained in excavating the canal. The latter plant has a capacity of 180 cubic yards an hour.

A preliminary survey of the entire area entailed the sinking of approximately 16,840 diamond-drill holes, and as operations progressed and more detailed information about underground formations was required, the footage of exploratory holes was tripled. The rocks of the region were laid down in Ordovician and Silurian times and, in general, the strata dip gently to the south-southeast 28 feet to the mile, though diamond-drill intersections (cores) indicate local dips up to 60 feet per mile.

From arch to invert, the various members exposed in advancing the tunnel faces are: Reynales dolomite, 12 feet; Neagha shale, 6 feet; Thorold sandstone, 8 feet; and Grimsby sandstone, 25 feet. Except for minor variations as excavating progresses, the arches are maintained on the lower contact of the Irondequoit limestone of the Clinton formation, thus insuring a roof of the greatest possible competence and determining the vertical elevation of the tunnels and their invert grade of about 28 feet per mile upward in the direction of the eventual flow. This explains why the ends of the two tunnels are at different depths.

Coarsely crystalline in texture, the limestone is dense and relatively unjointed and its upper and lower contacts are clearly defined. The upper 15 feet of the Grimsby member is massive and slightly stratified; but with depth the sandstone becomes more stratified and there is an increasing incidence of shale parting submembers. Some of the latter have a tendency to squeeze or flow under pressure and caused minor difficulties in benching operations until the routine was altered, as will be described in the concluding installment of this article.

The presence of the St. David Gorge, mentioned previously, necessitates terminating the tunnels at a point short of its south bank and carrying the water across and thence to the powerhouse by canal. In inter-Pleistocene times the gorge was the channel of the Niagara River from the Whirlpool to what is now Lake Ontario and was cut by the St. David River (comparable to the Niagara). During the Pleistocene era the region was invaded by two distinct ice sheets separated in point of time by a relatively mild recessionary period. It was during the second or Wisconsin glacial period that the land surface was eroded, leaving a heavy mantle of till that filled the gorge.

Because of the resultant filling and blocking of other outlets to the North, drainage for a time was southward to the Mississippi system, the rock contours showing that a broad, shallow channel extended southward from the Niagara in the vicinity of the intake works above the Upper Rapids. As the Wisconsin sheet retreated farther northward, and as the waters in the basin dropped, new outlets to the North were formed and, in time, one of them became the present Niagara Gorge from the Whirlpool to Queenston.

On the surface, the St. David Gorge is known to be some 2000 feet wide, but its depth is a matter of conjecture. It is filled with heterogeneous unconsolidated glacial till relatively poorly drained. Like in the case of the No. 1 power project, the only economic choice was a surface canal across the gorge, with enough space between the circular tunnels and the trapezoidal section of the open waterway for adequate hydraulic transition.

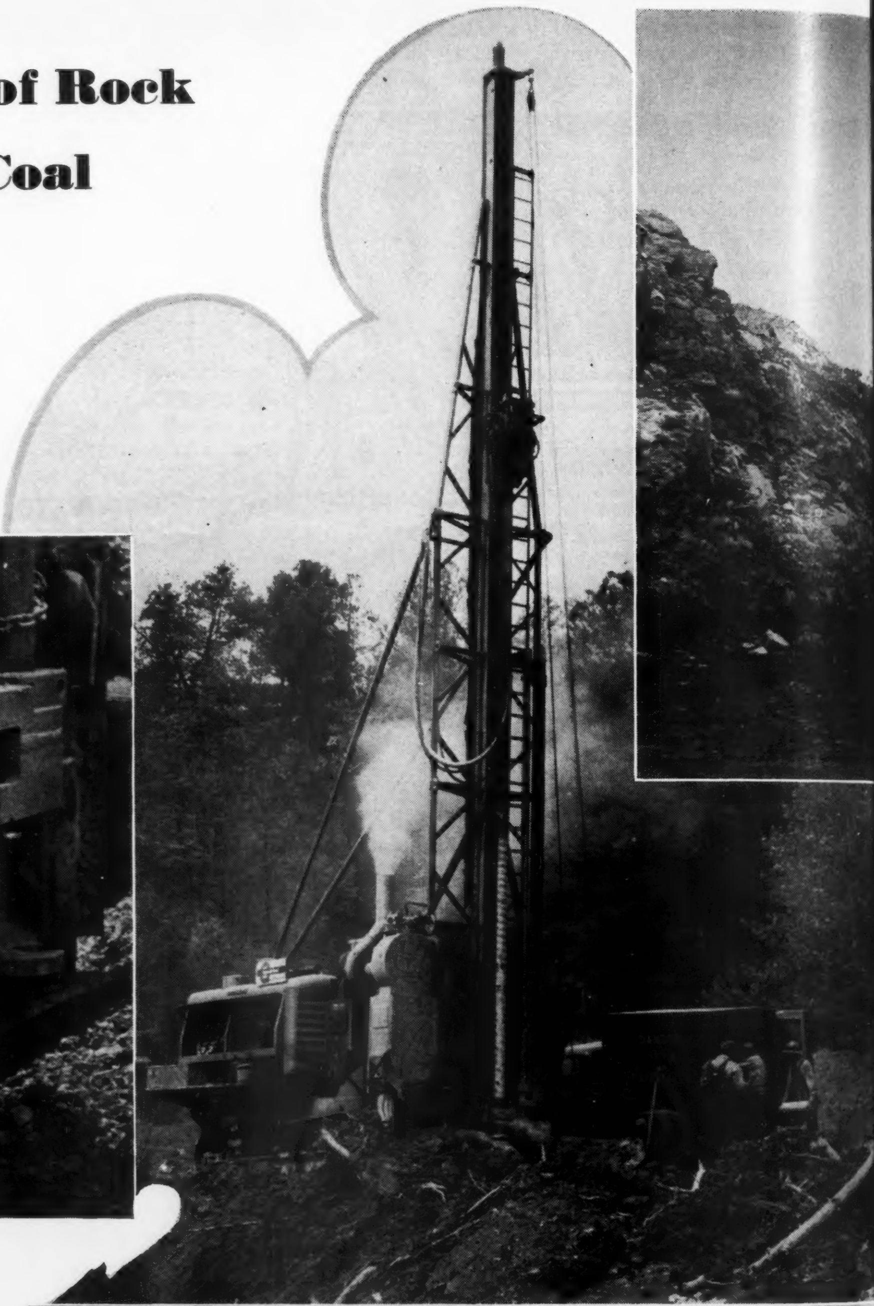
Except for the trapezoidal section, the rectangular or main stretch of the canal will be unpaved and unlined, the lower 50 feet of its 70-foot depth being in massive, coarse- to medium-grained crystalline Gasport limestone, a member of the Lockport formation that also supplies the project with concrete aggregate of excellent grade. The invert is in contact with DeCew dolomite which offers the excavators an excellent parting plane with a smooth surface and does not have to be paved.

The concluding installment will appear next month.

Digging 40 Feet of Rock to Get 2 Feet of Coal

Alabama Producer Literally Turns Mountain Over to Uncover Thin Seam of Mineral

Ted Slager



QUARRYMASTER AT WORK
Entirely air operated, this efficient heavy-duty drilling machine with a 50-foot tower (above right) puts down 40-foot holes through shale and sandstone at the rate of 80 to 100 feet per hour. The original Quarrymaster was a percussion drilling outfit, whereas this one literally bores its way through the rock by turning a typical oil-field type of cone bit, shown close up above.

CLEARING THE WAY
As the first step in the mining sequence, bulldozers clear away trees and brush and smooth the surface to facilitate subsequent drilling and excavating operations.

HARD-WON PRIZE

The picture at the left pretty much epitomizes the multiple-step excavating process. In the background, a Bucyrus-Erie walking dragline with a 165-foot boom and a 11-cubic-yard bucket is stripping overburden, shattered by drilling and blasting, from a 2-foot coal seam. In the middle-ground, just right of the coal truck, is an International high-lift truck removing the final few inches of earth and rock. In the foreground, coal is being loaded by a 1-yard power shovel.

OPERATING HEADS

Reed Jackson, left, superintendent of the job, and Newton H. DeBardeleben, president of the coal company that bears his family name.

SELDOM has Mother Nature been as kind to man as she has in an area of approximately 50 square miles around Birmingham, Ala. There she has deposited huge quantities of the three main ingredients needed by the steelmaker—hematite ore, coal to make the necessary coke, and limestone to serve as flux. In fact, it is said to be the only place in the world where these substances are found together in such abundance.

Coal underlies about 40 percent of the northern half of the state, and the total available resources are estimated to be 66,711,378,260 short tons, or enough to last 7500 years at the present rate of production. The principal iron ore, red hematite, lies chiefly in the region around Birmingham, and the richest deposit is located in a 14-mile strip between that city and Bessemer, Ala. Four large steel companies—Tennessee Coal, Iron & Railroad Company, Republic Steel Corporation, Woodward Iron Company and Sloss-Sheffield Steel & Iron Company—have taken advantage of the proximity of iron and coal and are mining both to supply their blast furnaces with those raw materials.

However, our story has to do with coal, and it would not be fair to tell it without introducing the pioneer De Bardeleben, Henry F., who played so important a part in the development of the Birmingham district and whose name is synonymous with Alabama's coal industry. (Originally, during America's revolutionary period, the name was Von Bardeleben, but as the wife of the early Von Bardeleben was of French ancestry he decided to substitute "De" for "Von.")

It all began in 1872 when Henry F. left his home in Prattville, Ala., to look for his fortune in the hills around Birmingham. He discovered and developed the state's original coking-coal seam, which he named the Pratt Seam in honor of his wife's family. The company he founded became the Tennessee Coal, Iron & Railroad Company in 1892. For years DeBardeleben's son Henry T. followed in his father's footsteps in the coal, iron and steel business and in 1912 organized the DeBardeleben Coal Company with the opening of the Sipsey Mine. In 1923 that concern merged with the Empire and Corona Coal companies to form the DeBardeleben Coal Corporation, which Henry T. headed and expanded for 36 years. Today one of the latter's sons, named Henry F. for his illustrious grandfather, is chairman of the board and another son, Newton H., is president.

The DeBardeleben's are literally turning over a mountain in their coal-stripping operations 34 miles north of Birmingham and are proving that it is possible with modern machinery and methods economically to strip overburden that other producers considered too expensive to tackle. The 80 miles or so of outcrop already explored does not lie in a straight line, but meanders through the mountainous countryside. The bed of coal is fairly flat and pitches 1° to the southwest. An average of 2 feet thick, the coal is of exceptionally high grade, having an ash content of only 2 percent. Some of it is processed in the company's own coking plant, but the bulk is sold in graded sizes to retail, commercial and industrial outlets. It is estimated that there is enough coal mapped out to keep the corporation busy for the next sixteen years mining about 5 miles of outcrop annually. The reserves represent a life of about 40 years.

Practically all the so-called easy coal—that which lies 10 to 20 feet under shallow overburden in the valleys—has long since been recovered by strippers. The early-day miners used auger drills to bore horizontal blast holes in the fairly soft-rock cover, but neither augers nor churn drills could profitably negotiate overburden exceeding 20 feet.

The 2-foot seam now being mined and known as the Black Creek Seam will in places be cleared of rock up to 70 feet in depth. This work is being done in stages or benches. The one being drilled and blasted at present is 85 feet wide, 500 feet long and approximately 40 feet deep. The amount of rock and overburden removed per ton of coal is 21 cubic yards, which is considered to be the economic limit under prevailing conditions.

The cycle of operations is as follows: First a caterpillar-dozer prepares a road or bench on a hillside by pushing earth around until there is a flat surface on which the big self-propelled drilling rig utilized can maneuver. It is an Ingersoll-Rand Quarrymaster, a self-contained machine equipped with a rotary drilling

AFTER THE COAL HAS BEEN EXTRACTED

A 50-foot wall left in one area after the coal strippers had passed by. The 2-foot seam of coal is hardly discernible at the bottom. A narrow band of low-grade fuel, too poor to warrant mining, may be seen about halfway up.

head operated by an air motor and using a Hughes Tri-cone or roller bit 7⅜ inches in diameter. The drill tower, which is 50 feet high, handles 40-foot steels. For the most part the drill is putting down 40-foot holes, each in one operation with no steel changes, bottoming them within a foot or two of the coal seam. For the few holes that are deeper, one steel change is required.

The blast holes are drilled in rows 16 feet apart and are on 18-foot centers. They are loaded with explosives in cylindrical cartridges from 5½ to 7 inches in diameter and 24 inches long, the number and spacing depending upon the respective amounts and distribution of sandstone and shale to be broken. Firing is done with delay primers. Powder consumption ranges from 0.3 to 0.4 pound per cubic yard of rock.

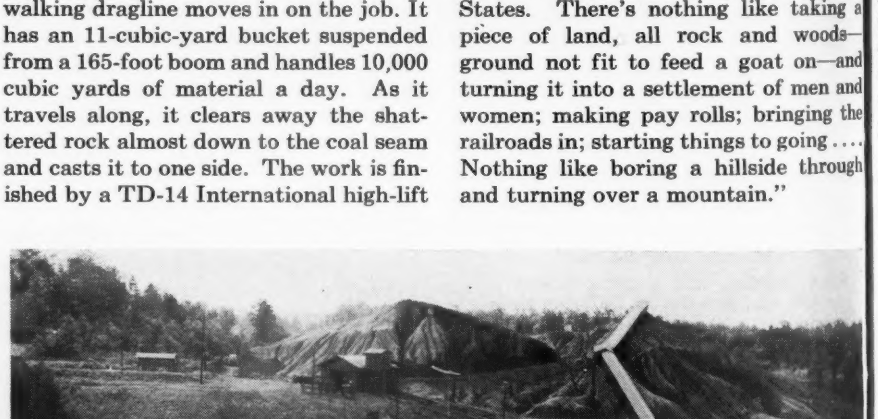
With the 7⅜-inch bit, the Quarrymaster drills from 80 to 100 feet an hour. The rock is about half shale and half sandstone. Generally, a thin layer of shale is found directly over the coal, but occasionally sandstone is encountered there. The rotating bit penetrates the formation under sufficient pressure to crush the rock into sizable chips which, together with the fines, are blown out of the hole to the surface by a continuous stream of air flowing down through the hollow drill steel. There is an efficient dust collector on the rig in which the cuttings are stored in two hoppers of generous size. The coarse rock fragments are used as stemming after blasting powder has been lowered into the hole.

The Quarrymaster is equipped with two compressors which supply air to operate the drill, clean the hole, serve the dust collector and drive the air motor that propels the machine. After the rig is spotted for drilling, three hydraulic jacks quickly bring it to a level, which is done only as a convenience where ground is uneven because blast holes can be put down at any angle at which the machine may be standing. A comfortable cab is provided to protect the operator from the heat of the sun or winter's cold.

Following drilling, a Bucyrus-Erie walking dragline moves in on the job. It has an 11-cubic-yard bucket suspended from a 165-foot boom and handles 10,000 cubic yards of material a day. As it travels along, it clears away the shattered rock almost down to the coal seam and casts it to one side. The work is finished by a TD-14 International high-lift truck which, because of the flat nature of the bed, removes the remaining material, leaving a clean coal face exposed. Then, without further blasting, a small 1-yard steam shovel scoops the coal directly into trucks for transportation to the nearby washing, cleaning and sizing plant which was recently completed and which is said to be the most modern one in the South. It generally takes five days to drill out a bench, five days to strip off the rock and five days to take out the coal.

The washery requires about 2300 gallons of water a minute, and as no large natural streams are nearby, it is used over and over again for cleaning coal. The company has converted a large abandoned strip-mine pit fed by springs and drainage into an impounding reservoir. The supply from this source serves as make-up water and is delivered through a 6-inch pipe line, 8680 feet long, into a storage basin at the processing plant. The dirty water from the latter flows into a settling basin and is pumped back into the washery reservoir.

In addition to the extensive mining operations described, the corporation also owns a large coke-and-coal chemicals plant at Holt., Ala.—enterprises all laid on the foundation built by the pioneering Henry F. DeBardeleben. The caliber of that picturesque man is best expressed in his own words quoted by Ethel Armes in her book on *The Story of Coal and Iron in Alabama*. "I'd rather be out in the woods on the back of a fox-trotting mule with a good seam of coal at my feet than be President of the United States. There's nothing like taking a piece of land, all rock and woods—ground not fit to feed a goat on—and turning it into a settlement of men and women; making pay rolls; bringing the railroads in; starting things to going.... Nothing like boring a hillside through and turning over a mountain."



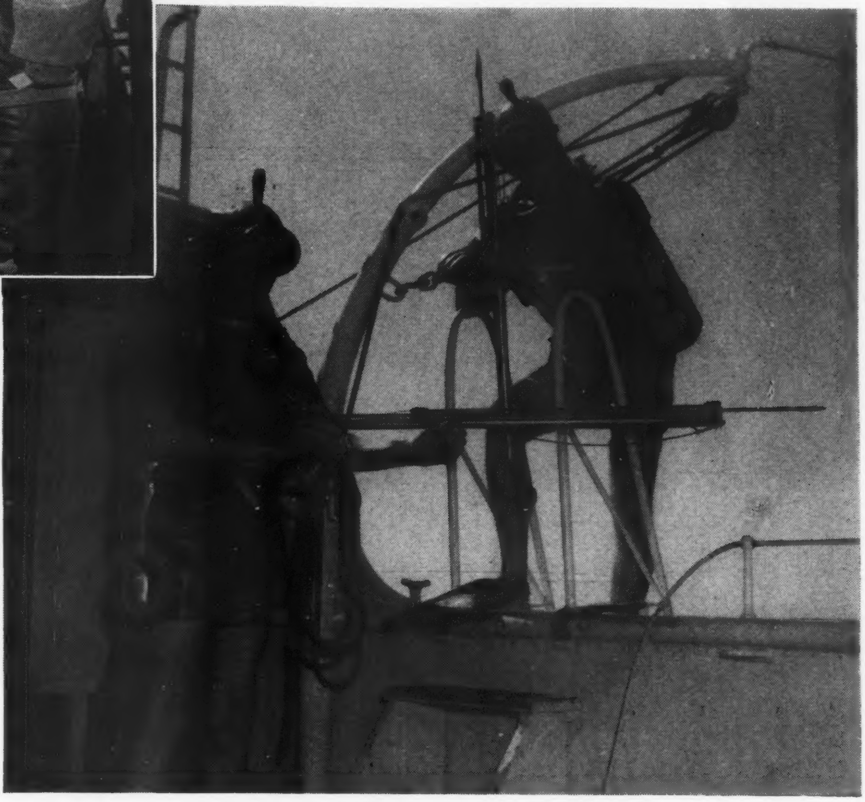
COAL-CLEANING PLANT

The strip-mined coal is trucked to this washery for cleaning and sizing, then shipped to market. The refuse is conveyed to the disposal area in the rear.

Compressed Air Under the Waves

The Aqualung Is Opening Up a Strange New Underwater World to Mankind

Robert J. Nemmers



INVENTOR AND MANUFACTURER

Capt. J. Y. Cousteau, originator of the submerging aid, is shown in the upper picture being helped into an air-insulated cold-water diving suit by Rene Bussoz who heads the U. S. Divers Company, American licensee for manufacturing the Aqualung. Bussoz and the unidentified man are wearing short American-made suits. In the lower picture, Bussoz and Paul Arnold are ready to go over the side of the "Velero IV" on a hunting expedition off Palos Verdes, Calif.

THERE is another world close to ours—a world of fantastic shapes and proportions, of brilliant colors and strange creatures. It is made up of the mighty seas that encompass three-fourths of the earth's surface. Far back in the memory of man lie dreams of the conquest of these challenging bodies of water. Man has accepted the challenges as best he could. Since the dawn of recorded history, and probably before, he has looked to the seas as a source of food. He has sailed upon the surface of the oceans, using them as highways to distant lands. Today he is well on his way to reclaiming some of the minerals washed into the seas through countless years of erosion.

Yet almost every man nursed a strong desire in his youth when he frolicked in the "ol' swimmin' hole," whether it was a lake, an ocean or a dammed-up creek. That wish is still being voiced by boys when they ask one another, "Wouldn't ya like to be able to swim like a fish and breathe underwater?" Today, a group born of these aspirations—*pisces homo sapiens*, menfish—has invaded the seas. Although that classification will probably never be accepted by an anthropologist, man today swims beneath the waves unencumbered by a heavy diving suit, helmet, shoes and air hoses extending to the surface. He is able to move freely to a depth of only around 130 feet right now, and is limited to about two hours' submersion, but within that realm he is undisputed master. Furthermore, this is not reserved for the classical he-man type; even women and children can swim and play and work there. This is a tribute to the safety and simplicity of the Aqualung, the mechanism by which man has answered one of the sea's challenges.

The Aqualunger is an odd-looking creature. Clad from head to toe in a close-fitting rubber garment, with the face obscured by an oval eye shield and an ungainly rubber "gill" from which two flexible spiral-wound hoses extend to a small regulator and tank assembly strapped on his back, he looks more like a man from Mars than from the Earth. Out of water he is graceless and slow on finlike feet. Underwater he glides and flits about like a bird; indeed, he is nearly weightless because of the buoyancy of the water. Behind him as he swims, bursts of bubbles in steady measured rhythm issue from the air regulator.

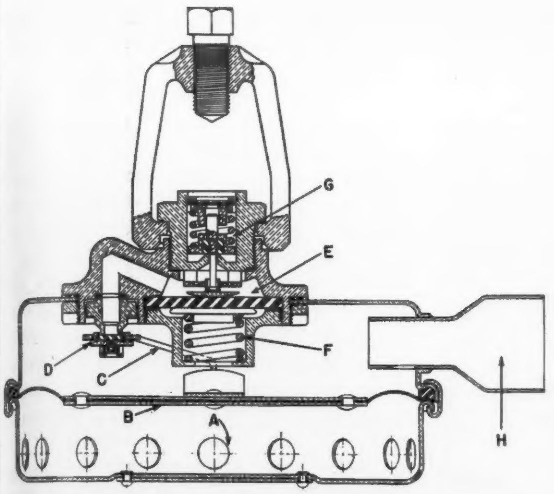
An ingenious contrivance, the regulator is the heart of the Aqualung system of diving. It efficiently reduces air pressure of more than 2000 psi to ambient pressure, regardless of what the latter may be, and then meters the air to the lungs of the diver as he demands or inhales it. An accompanying drawing shows the device in detail. None of the air in the tank or tanks, each of which holds 70 cubic feet of free air, is wasted. Built into the mechanism is a constrictor that warns the diver when his air supply is running out by suddenly making it hard for him to breathe. When this happens he knows that he has plenty of time to return safely to the surface if he starts to ascend immediately.

Aqualungs are now utilized the world over. Sportsmen armed with arbaletes, a crossbow that throws a spear, go deep-sea hunting with them, and men, women and youngsters find this unique pastime

MARINE HUNTERS

Outfitted in a skullcap and full-length rubber suit to ward off the chill of cold water, an Aqualung diver is pictured at the upper left about to descend in quest of swimming game. Under his left arm is an arbalete, a modern version of the crossbow, that throws arrowlike steel shafts. Lead weights around the man's waist will take him down quickly. The picture at the left shows A. F. Vander Kogel, diving specialist for the New York sporting goods firm of Abercrombie & Fitch, being hauled to the surface with a 150-pound member of the grouper family that he bagged with the carbon dioxide-powered spear gun in his right hand. In the other view is a diver with a 9-foot tiger shark that had to be attacked with five spears before succumbing.

PHOTOS BY E. L. FISHER AND SUBMARINE STUDIOS, MIAMI



HOW REGULATOR WORKS

Because it unfailingly supplies vital air to the diver, the demand regulator (above) is called the heart of the Aqualung. Water entering the base through holes "A" acts against diaphragm "B," which forms the bottom wall of the lower chamber. Movement of the diaphragm actuates valve "D" through lever arrangement "C," causing air to bleed from the upper chamber "E" into the lower one until the sea pressure is equalized. The pressure in the lower chamber, in combination with the spring "F," then acts to halt the flow of air from the diver's tank through valve "G." When the diver's breathing removes air from the lower chamber through port "H," the cycle repeats itself and is capable of matching the fastest breathing rate. Air exhausted from the diver's lungs is discharged into the water through a valve just below diaphragm "B." Diaphragm and spring-loading devices are so calibrated that the mechanism works on a pressure differential of only 2 to 5 psi, and this is readily produced by the lungs.

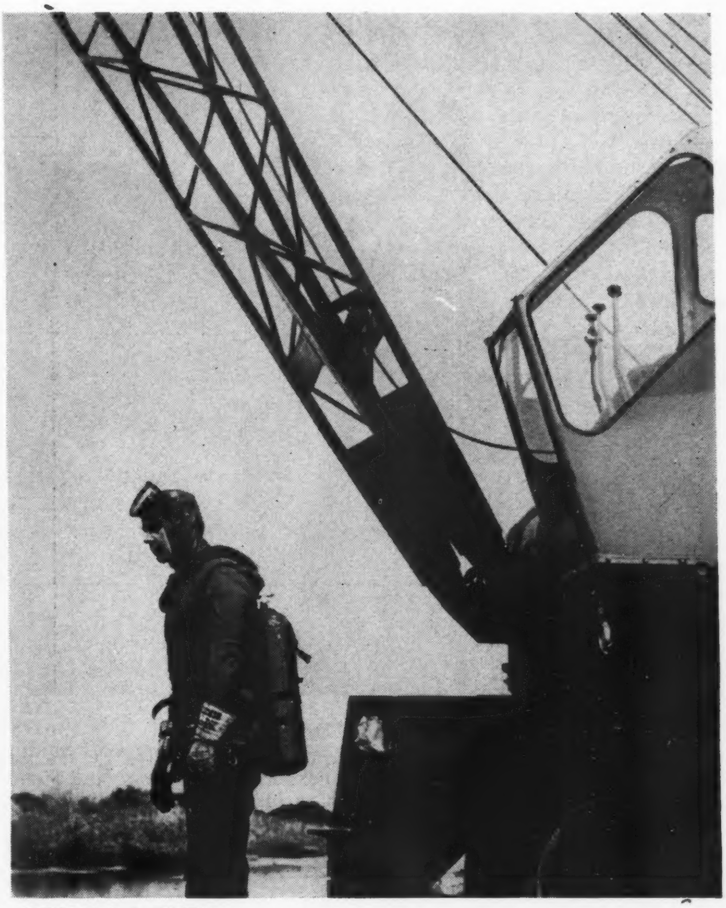


PHOTO BY E. L. FISHER

AQUALUNG SALVOR

C. F. Diercksmeier of Aqualung, Inc., shown while working on the recovery of a 17-ton load of reinforcing steel that was dumped into a canal by a trailer truck that went out of control.

fascinating. Scientists have adopted the equipment as a means of observation and research, and even the most unathletic of them can use the Aqualung with ease and gain first-hand knowledge of undersea conditions for which they previously had to rely upon the untrained eyes of others. Today the outfit is making it possible to add quantities of material to the world's book of facts about submarine creatures and plants. Underwater films of a scientific nature have so enthralled the layman that many of them have become box-office successes.

Most of the Aqualung's industrial applications are of the regulation diving-dress class and are performed more easily and cheaply because the diver is not hampered by heavy clothing and long lines. Off the Cape Verde Islands near the coast of Africa the Shell Oil Company of Portugal, Ltd., laid a submarine pipe line out from shore for a distance of 3300 feet to speed tanker discharge and turn-around at that important bunkering port. All the underwater operations were performed by a French diver and two local assistants using Aqualung equipment. The latter is definitely superior to the familiar rubber outfit in searching for small objects on the floor of the ocean. The leaden boots the helmet diver wears muddy the waters as he shuffles along, thus obscuring the view. The free-swimming Aqualunger, on the other hand, can glide along with his nose within a foot of the bottom if necessary without disturbing it.

The Aqualung represents the cumulative ideas and experiences of centuries. Many old manuscripts tell of crude attempts at constructing diving apparatus, and in one is a drawing of a man underwater breathing by aid of a bellowslike arrangement made of goatskin. Goggles enabling the wearer to see submerged have been known for hundreds of years. However, the development of feasible equipment had to await the day of reliable compressors and safe rubber hose.

The conventional method of delivering air to a diver through a long rubber hose obviously limits his working radius. In addition, he is entirely dependent upon a power supply that might fail without warning. Should that happen, his chances of reaching the surface without aid would be remote, even in shallow water, because of the weight of his suit. More than three-fourths of the air compressed for his consumption is wasted—bubbling uselessly from the exhaust valve on his helmet. All things considered, the Aqualung has an advantage over the helmet-type gear because it permits the wearer to swim like a fish with no encumbering lines that are always in danger of fouling.

During the mid-1930's, individuals seeking amusement, excitement and sometimes danger took up the age-old sport of skindiving. Those venturesome men gained fame along the coast of the blue Mediterranean Sea for their underwater exploits. Wearing no breathing apparatus and holding their breath for as long as three minutes, they hunted the depths with slingshots that threw spears at creatures which provided 80-pound fillets. Having caught glimpses of the submarine wonderland, they longed to spend more time there than their lightninglike dives permitted.

One of the first inventors who tried to make this possible was a Frenchman, Le Prieur, who slung across his chest a tank of compressed air and ran a hose from it to a rubber mouthpiece. He regulated the flow of air to his lungs by an interposed hand valve. At the best, this was a makeshift, for it was necessary to readjust the valve every foot he descended or rose. Consequently he spent more time providing himself with air at the proper pressure than swimming or looking around. Besides, at least half of the limited air supply was wasted in the process of adjustment.

The Le Prieur lung, however, did whet the appetites of others for a more work-

PHOTO BY JULIUS DOWN

THEY SAY IT'S FUN

Among the growing number of Aqualungers who dive for the thrill of it are Dorothy and Earl Warren, Jr., (right) children of Governor and Mrs. Earl Warren of California. They are shown with an unidentified companion ready for a trip into Neptune's domain.

able mechanism, and that brought about the development of oxygen apparatus modeled after the respirators used in gaseous mines and in fighting fires. Those units were self-contained and purified the air exhaled by the diver by passing it through soda lime which removed the carbon dioxide so the oxygen could be recycled. They provided a real opportunity for observation and sport while swimming beneath the surface. But they had one serious drawback. At depths below 45 feet the diver suddenly had convulsions and blacked out because of the extremely high concentration of oxygen in the bloodstream.

Then in 1942, two French scientists, Captain* J. Y. Cousteau of the navy and Emile Gagnan, produced a regulator that furnished air as required and that later became the main element of the Aqualung diving system. Cousteau was working with the Free French Security Forces at the time and functioned under the guise of a producer of scientific movies, while Gagnan was working on a method by which natural or manufactured gases could be substituted for gasoline in motor vehicles. The demand regulator was based on one the latter had conceived for the gas-burning internal-combustion engine.

The first regulator was tested outside of Paris in the winter of 1942-43 and was found to operate perfectly when the swimmer was in a horizontal position. However, when his head was down it was nearly impossible for him to breathe, and when his head was up the air rushed wastefully from the exhaust valve. Investigation proved that the exhaust was either higher or lower than the intake under those conditions, and though that resulted in a difference in water pressure of only 6 inches it was the cause of the trouble. It was corrected by placing the exhaust valve within an inch of the diaphragm that maintains a balance between the regulator and the ambient pressure. That was virtually all the adjustment the regulator needed.

Cousteau then took his Aqualung to Marseilles where he and Phillipe Tailliez, another French naval officer, and Frederic Dumas, known as the world's most experienced skindiver, experimented with it. There they discovered that German occupation forces were testing a similar unit in nearby waters in the hope of developing a free-swimming diving apparatus for military purposes. What the German Ministry of War failed to do with plenty of Reichmarks, Cousteau and his friends did with a minimum of funds right under the noses of their enemy. Their adventures and findings during this period and after the war, when they formed an underwater research group as an arm of the French Navy, are described in a fascinating book, *The Silent World*, by Cousteau and Dumas.

But before menfish could invade the sea with impunity, many problems had to be solved by compiling empirical data based on hundreds of dives by Cousteau and his friends. One of the first was how to keep warm while underwater. This had bothered them even before the advent of the Aqualung, for the chilling sea drained their energies. So they developed a lightweight rubber suit that is worn over woolen undergarments and that offers indefinite protection in the coldest waters. It comes without arm and leg coverings for waters above 55°F.

Another problem that had to be answered was the safe depth limit of the apparatus, and that could be determined only by dangerous experiments. Maurice

WIDE WORLD PHOTO

CIVIL AIR-PATROL FROGMEN

The Navy's vaunted Frogmen, whose exploits have been recorded in a popular motion picture, wear Aqualung suits. The diving aid has also been adopted by Civil Air Patrol forces. Members of the Salem, N. H., wing are shown here being trained to look for lost objects in the water, sunken planes and persons who have lost their lives by drowning.

*The equivalent United States naval rank is commander.

Fargues, an early diving companion of the Cousteau group, descended to 396 feet, deeper than anyone breathing unmixed air has ever gone, and wrote his name in indelible pencil on a white marker board at that level to testify to his achievement. (To measure the depth of each dive, a series of small marker boards was fastened at 5-meter (16.5-foot) intervals to a heavy shot line suspended from the surface craft).

Unfortunately, Fargues never survived that experience because he was a victim of another danger—nitrogen narcosis or rapture of the deep. This affliction is described as a drunken feeling of superiority over the sea and may cause a diver to do such a foolhardy thing as tear off his mouthpiece and offer it to a passing fish. Nitrogen narcosis is believed to be attributable to supersaturation of the body tissues with nitrogen and affects the central nervous system. It occurs at approximately 210 feet and is in no way related to the bends or caisson disease. It is believed that a mixture of oxygen and helium rather than the normal atmospheric mixture of nitrogen and oxygen might lessen or negate the effect.

As a result of the courageous explorations of Cousteau and his associates and others it has been possible to establish data governing depths at which Aqualung equipment can be safely utilized. In waters 130 feet deep, professionals can do hard work and even amateurs can swim without risk. Between 130 and 210 feet, skilled divers can perform light tasks and observational duties. But the realm between 210 to 300 feet can be explored with reasonable safety only by those highly trained, while that below 300 feet is so dangerous that invasion is believed to be flirting with death.

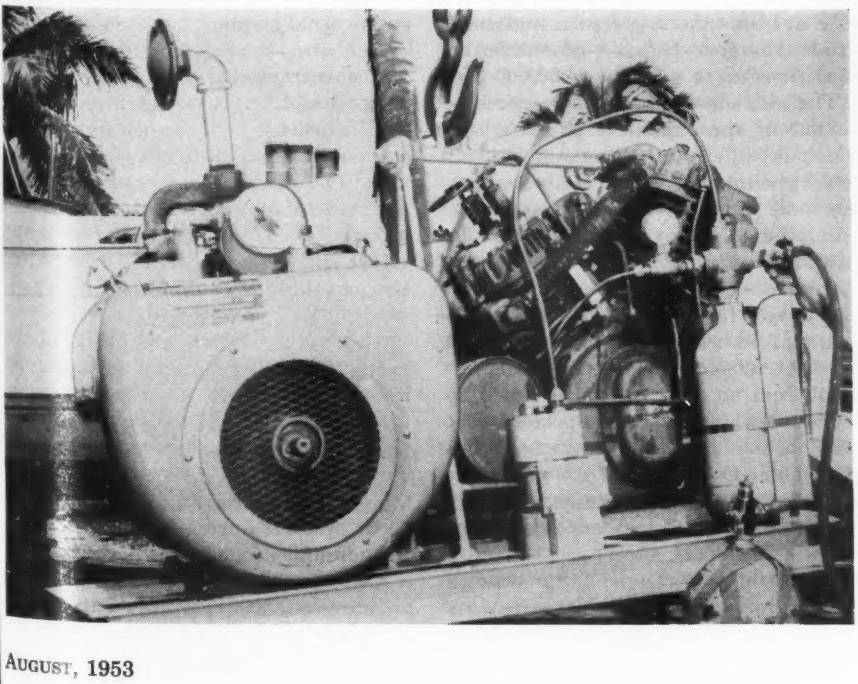
One of the afflictions to which the amateur is exposed is the bends. This "disease" attacks a diver when he remains under high pressure long enough for the nitrogen in the air he breathes to go into solution in his blood and to permeate his body. If he returns to the surface suddenly, the nitrogen in his body fluids and tissues expands, it literally froths, and the little bubbles may cause severe muscular cramps, paralysis and even death. Fortunately, this risk can be easily guarded against by surfacing in stages, pausing intermittently to allow the nitrogen to leave via the lungs while the body is still under partial pressure.

Aqualungers have set up decompression tables which, if followed, insure a safe swim and absence of the bends. For example, a diver working at a depth of 100 feet for a period of 25 minutes does not have to undergo decompression other than that brought about by rising slowly to the surface. However, should he remain there for 75 minutes, then he must pause at the 20-foot level for 27 minutes and at the 10-foot level for 21, making a total decompression period of 48 minutes. By following these rules, an Aqualunger—any diver, in fact—enjoys safety; by violating them, he invites disaster.

The future of the Aqualung seems bright. The U. S. Divers Company, the United States manufacturing licensee, lists among its users the United States, French and British navies; the universities of California, Washington, Wisconsin, Stanford and Southern California; as well as the Pacific Oceanic Fishery Investigations, the Fish and Wildlife Service, the U. S. Bureau of Reclamation, the Scripps Institute, the American Red Cross, several maritime organizations and thousands of sportsmen. Perhaps one reason for its popularity is the fact that it is relatively cheap—the purchase price of a de luxe lung and accessories, including hunting equipment, being less than $500. Upkeep and operation, too, are inexpensive.

However, there is the matter of compressed air at 2000 psi. That does seem to pose something of a problem for the individual who wants to go Aqualunging just for the fun of it. It has been suggested that these enthusiasts form clubs and prorate the cost of a machine among the members. For industrial uses, where high-pressure compressors are not available, the U. S. Divers Company is also offering a demand regulator known as a Hookah that permits connecting the Aqualung to a 150-psi machine by hose lines. While the latter do restrict the movement of a diver, still there are many commercial fields in which he can, nevertheless, perform valuable services.

Forecasts of possible uses for the Aqualung sound a little like fiction, yet man is turning more and more to the sea as a source of food and energy. It may well be that the deep-sea diving rig of the future will be modeled upon the Aqualung. It is also possible that one day we will see regiments of men working and playing beneath the waves. Whatever the final applications, it is certain that one more useful tool has been added to our stock and that it will help us to know more about the world in which we live.



AIR-CHARGING FACILITIES

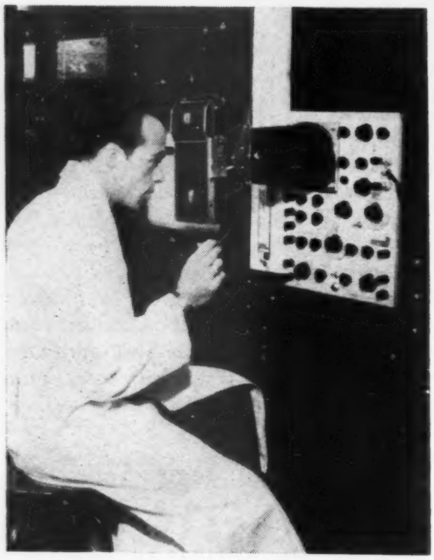
Pictured at the left is an Ingersoll-Rand compressor that delivers air at 2000 psi pressure for charging Aqualung cylinders. It is used by Aqualung, Inc., in Florida. The hook at the top is in a ring by which the machine is lifted aboard a ship or onto a truck for service away from the base. The other view shows an Aqualung's air cylinder being filled while submerged in a can of water that cools it so as to condense any moisture that may remain in the air after it has passed through a moisture trap and a spiral aftercooler on its way from the tall vertical storage reservoir.

Pneumatics in the Sky

Bureau of Standards Seeks Data on Uses of Air Power in Aviation

CALIBRATING GAUGES

Pressure acting on the gauges at the upper right is balanced against the pull of gravity on a group of weights supported by the piston of a precision dead-weight gauge on the table.



RECORDING PRESSURES

Rapidly changing air pressures are recorded by focusing a high-speed camera on a cathode-ray oscilloscope.

RECENT trends towards high-altitude flight and more efficient utilization of weight and space in aircraft have led to a much wider application of pneumatic systems for the purpose of performing such high-speed operations as extending and retracting the landing gear, ejecting the emergency canopy or seat, gun charging and rocket ejection.

Although compressed air has been used for many years, air-borne pneumatics is still in an early stage of development. In view of the high actuation speeds and operating pressures now being considered, a comprehensive program of research and evaluation is needed. To meet this requirement, a program for the study of high-pressure pneumatics has been established by the National Bureau of Standards at the request and with the coöperation of the Airborne Equipment Division of the Navy's Bureau of Aeronautics. Although primarily directed towards the needs of military aviation, the efforts of the NBS pneumatics laboratory should find wide application in the aircraft industry as a whole and in other fields of high-pressure technology.

Under the direction of Dr. Milton M. Slawsky of the NBS Heat and Power Division, the laboratory conducts research basic to the design and evaluation of compressors, storage tanks, accumulators, valves, and other air-borne pneumatic equipment. It also obtains fundamental data in anticipation of future design requirements, develops laboratory procedures for the study of newly developed components, and renders technical assistance in the preparation of specifications for pneumatic devices.

Available facilities include a compressor system furnishing air at pressures up to 500 atmospheres, a specially designed low-temperature box for testing components at temperatures down to minus 95°F at atmospheric pressure, and an altitude chamber capable of simulating conditions up to a height of 80,000 feet.

The altitude chamber has a working volume of approximately 25 cubic feet, which is sufficient to accommodate an entire pneumatic system. Both temperature and humidity controls permit the simulation of flight conditions at high altitudes, and studies can be made over the entire temperature range from minus 100° to plus 150°F. Contained in the low-temperature box is a 3.75-cubic-foot test chamber refrigerated by circulating alcohol from an adjacent bath chilled by dry ice. Air under pressure passes to the component under study through a built-in cooling coil. A flow of 150 cubic feet per minute can be maintained through the system for extended periods at minus 90°F.

The evaluation of pneumatic systems and components involves measurements of pressure and temperature under transient, pulsating and steady-flow conditions, as well as of volume rate of steady flow. The equipment used by the laboratory for this work has been designed to permit automatic recording, adaptability and mobility wherever possible. Static pressures are measured by a bank of Bourdon-type gauges, which are calibrated at frequent intervals against a dead-weight piston gauge of extreme accuracy throughout the range of pressures from 25 to 6000 psi. Transient pressures are determined by means of temperature-compensated strain-gauge pressure pickups calibrated at static pressures. The strain gauge is employed in the usual manner, but the signal is fed either into a recording potentiometer (for slow transients) or through a strain-gauge amplifier to an oscilloscope (for fast transients). Chromel-alumel thermocouples are used to measure temperature. To decrease response time, they are made of 36-gauge wire with as small a junction as possible. For measurements in high-pressure air streams, the thermocouple is built into a high-pressure gland.

The work of the laboratory in the evaluation of pneumatic systems has been concentrated on two problems: (1) determination of the factors governing the most efficient storage and working pressure, and (2) determination of the pressure and energy losses in pneumatic systems during transient flow.

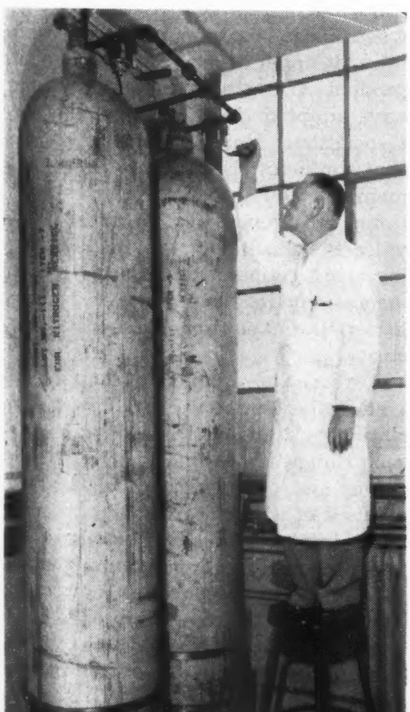
Preliminary calculations on the first of these problems indicate that storage pressures of 3000 psi are justified and

that perhaps even higher pressures may yield further savings in weight and space, but with diminishing returns. The problem is complicated by the variety of possible systems, but there is reason to believe that a rational basis can be developed for estimating the optimum storage and working pressure.

The work on the second problem involves first the study of pressure and energy losses in a pneumatic system during steady flow and then the correlation of these losses with those occurring during transient flow. The results to date give a satisfactory agreement between theory and experiment for steady flow. From a practical standpoint, this means that it is possible to make an *a priori* estimate of the losses to be expected in any given pneumatic system. The theoretical calculations are now being extended to include experimental results obtained under transient-flow conditions.

Although the primary objective of the laboratory is the solution of practical problems in pneumatic design, basic information must be gathered and analyzed in order to understand the relative importance of various design parameters. It is therefore conducting parallel theoretical and experimental investigations on the physical phenomena associated with the thermodynamics and mechanics of fluid flow.

At present the only published data on the high-pressure properties of air are



STORAGE TANKS
Each vessel contains 10 cubic feet of air under a pressure of 3000 psi.

the Joule-Thomson measurements, which extend to 220 atmospheres. To obtain the data needed in this field, the NBS Thermodynamics Section has installed laboratory facilities and apparatus for measuring the pressure-volume-temperature (PVT) relations of air from the lowest temperatures to 350° Kelvin (170°F) and at pressures up to 300 atmospheres. With the application of existing theory, the experimental measurements obtained in this range will permit accurate determination of the thermodynamic properties of air at the high pressures being considered for future designs. The apparatus can also be used for PVT measurements on other technically important gases that have been considered for pneumatic applications.

On the basis of the existing data for the principal constituents of air and the limited data for air itself, tentative tables and charts of the thermodynamic properties of air have been calculated from 2 atmospheres to 5000 psi. The Joule-Thomson coefficient, specific heat, enthalpy and entropy have been computed as functions of temperature and pressure, and graphs are in preparation.

Study of a large variety of pneumatic components has brought to light several inadequacies in current pneumatic testing practice. Some of the commonly accepted definitions and test procedures have proved to be ambiguous. As a result, it has been necessary to reëxamine the bases on which existing tests were set up. A careful analysis has been made of the performance of various components to determine the elements or characteristics that are of real importance to their proper operation.

In the course of this work, a method was worked out for describing the pressure drop across any pneumatic component in terms of a single characteristic curve.* This new approach permits the rating of a valve with extreme economy of time and much less ambiguity. Previously, the flow characteristics of a component were described by a family of flow curves, which were plots of flow rate versus downstream pressure for various values of upstream pressure. Numerous careful measurements were necessary to provide the data for such a set of curves. Bureau workers investigating the problem found that when the ratio of the downstream pressure to the upstream pressure is plotted against the ratio of the flow rate to the upstream pressure, a characteristic curve is obtained which is unique for the component under study.

Moreover, inasmuch as analytical formulae are available for plotting these characteristic curves, and all have one point in common, any given characteristic curve is completely determined by

GAUGING HIGH-PRESSURE AIR
Mobile instrument and control panel for measuring the flow of high-pressure air.

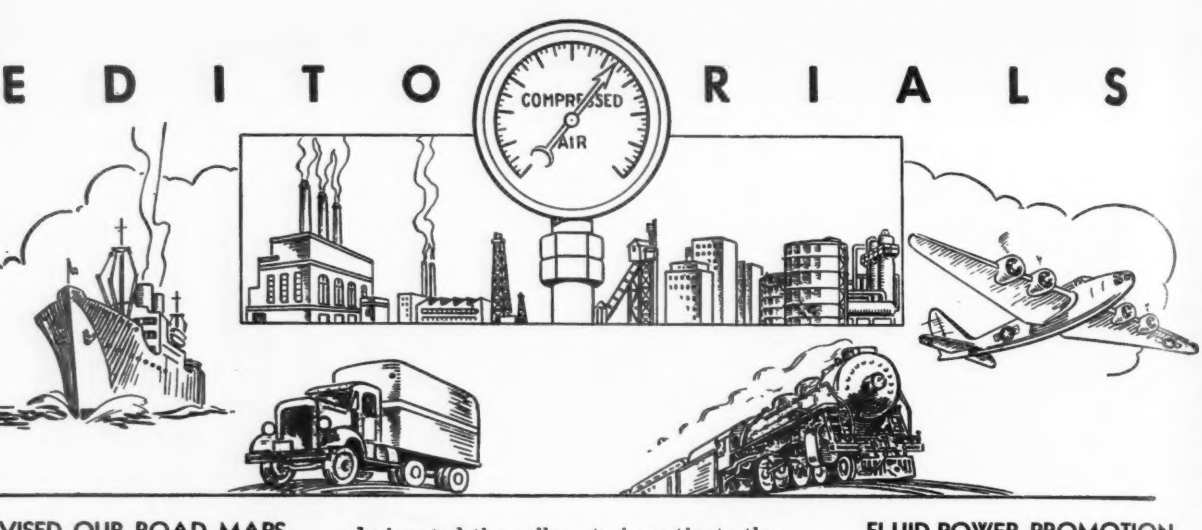
specifying one other point. Thus, NBS study shows that the complete behavior of a pneumatic component can be specified simply by the measurement of a single value of the flow rate for a given value of the ratio of downstream to upstream pressure. The value of the flow rate where the ratio of pressures is 1:2 has been designated the "flow factor" and is used by NBS to describe the complete behavior of a pneumatic valve in terms of a single quantity. The flow factor is a constant for a given component, and once it is determined either by experiment or theory it can be used to predict valve performance for a wide range of upstream conditions. It is also possible to combine analytically the flow factors of a number of valves into an over-all flow factor, which will serve to determine the behavior of the more complex system composed of the separate valves in series.

In the short time since its establishment, the pneumatics laboratory has made progress in the development of facilities, instrumentation, and experimental and theoretical techniques for the analysis of pneumatic systems. Continual effort has been made to maintain a balance between the practical and sometimes urgent requirements of the designer and the more basic aspects of the problems studied. It is believed that time spent on the more fundamental studies will eventually be of great value in the solution of technical problems arising in connection with pneumatic systems where high flow rates, short response time and rigid cycling schedules are specified.

*"A Method for Predicting Pressure Drops in Pneumatic Systems," by M. M. Slawsky, A. E. Schmidlin and Molutzky, S.A.E. Preprint No. 81 (1953).

EDITOR'S NOTE: Summary of a technical report published recently by the National Bureau of Standards.

EDITORIALS



HE REVISED OUR ROAD MAPS

THE man who had more to do with creating our nation-wide highway system than anyone else recently retired from active service. He is Thomas H. MacDonald, and he did such a good job as head of the Bureau of Public Roads for 34 years that no president, regardless of political affiliations, dared risk displacing him. Starting in 1919, or shortly after the Federal Government became interested in highway affairs, he administered its expenditures of billions of dollars and largely formulated its policies. In all truth, he revised the highway map of the country and guided the transformation from mud and ruts to macadam and concrete.

When MacDonald was called to Washington he was, at the age of 38, already a veteran and an expert in highway matters, previously having devoted sixteen years to that field of work. There was, we are sure, little serious interest in roads in 1904. Henry Ford had been building automobiles only a year, and there wasn't a gasoline filling station in the land. Yet at that time young MacDonald entered upon his career in road designing, although the truth is that his first efforts were aimed at smoothing the way for plodding Dobbins rather than rubber-tired Tin Lizzies.

In 1904, MacDonald was a 23-year-old senior student in civil engineering at Iowa State College, to which he had transferred after a year at a teachers' college. For some reason he had exhibited a liking for highway engineering, although we wonder if that term had then come into usage. Fortunately for the motoring millions who were to throng the roadways in afteryears, Iowa State had Dean Marston, an excellent educator with a keen understanding of his students and a desire to direct them along the lines in which they showed the most talent. At his suggestion, MacDonald based his graduation thesis on a study of the farmers' needs of highways and the force required to pull a wagon over different types of roads.

In the same year the Iowa Legislature designated the college to investigate the state's rather crude roadways and to make recommendations for improving them. MacDonald was assigned the task with the rank of assistant professor. This led to his appointment as state highway engineer in 1907. Six years later, when the highway law was revised to create a commission with authority to coördinate roadbuilding throughout the state, he was made chief engineer. In that post he had a hand in Iowa's becoming one of the first states to establish an integrated road system. Approximately one-third of the 6400-mile network had then been graded, drained and adequately bridged, and plans were being drawn to begin hard surfacing it when MacDonald was asked to go to Washington to take charge of the national-highway effort.

Federal Aid to the states in roadbuilding had been authorized by Congress in 1916, but had not been put into effect, and getting it going was MacDonald's first big job. At the outset he sought the advice and coöperation of state-highway officials, a practice that he continued to follow. As a result, there was rarely friction between national and state highway interests. When Federal Aid was instituted, practically all industrial plants were strung along railway lines, there were no surfaced roads connecting the large cities and farmers were mostly isolated. All this was altered during MacDonald's tenure in office.

He gained world-wide acceptance as an authority on highway matters and received numerous honors and decorations from foreign governments. Realizing the value of obtaining public support of his actions, he wrote profusely on the subject of roads and spoke frequently at highway meetings throughout the nation. His office was unblemished by suspicion of wrong doing of any kind and was never the target of investigators. Upon his retirement, a national highway magazine, *Roads and Streets*, editorialized him under the heading "Mr. Highway." Unquestionably, the title fits him, and he earned it.

FLUID-POWER PROMOTION

MANUFACTURERS of similar types of equipment have common problems and objectives. For example, though they may compete with one another, all are eager to advance their branch of industry and to promote the use of their products in preference to others that may be offered for the same purposes. They are also mutually concerned with establishing and maintaining certain standards to make sure that their commodities will win public acceptance and confidence. In short, there are many things that can be handled best by the industry as a whole rather than by its individual members.

To make such concerted action possible and to provide a clearing house where ideas of common interest can be brought under discussion, makers of like products, from pins to perambulators, have adopted the medium of the trade association. It is an old idea and one that works for the best interests of both members and public. In times of national emergency, for instance, it provides the machinery for quickly bringing about coöperation among the entire membership for the purpose of supplying materials and equipment essential to security.

A recently organized group of this kind is the National Fluid Power Association. It includes manufacturers of such things as pneumatic and hydraulic valves and cylinders and related products, all of which are steadily becoming more important in various industrial processes. At the organization meeting, 45 of these concerns were represented. They elected officers, adopted a statement of objectives and took care of other preliminaries to active functioning.

The term "fluid power" as defined by the group refers to all systems for the transmission, application and control of hydraulic and/or pneumatic power. All American concerns engaged in the design, production and distribution of components of these systems are eligible for membership in the association.

This and That

Britain's Largest Casting

A 170-ton steel casting, the biggest ever poured in the British Isles, was recently shipped to the United States for incorporation in a machine being built here in connection with the defense program. It is one of several turned out by the English Steel Corporation, Limited, of Sheffield. Three open-hearth furnaces were required to produce the 210 tons of liquid metal used in pouring it. After allowing six weeks for cooling, the massive casting was loaded onto a specially constructed truck for transport to a pier in Liverpool.

* * *

Spray-on Surgical Bandages

A plastic film called Bonoplast is being used successfully in Sweden as a substitute for the traditional surgical dressing of cottonwool and gauze. It is a viscous liquid that dries into a transparent, pliant film a few minutes after application. It has the same degree of permeability as the human skin and thus permits the latter to "breathe." Moisture given off by the skin passes through it instead of accumulating, and hence does not obscure the view of the wound or incision. In the same manner, blood seeps through and can be wiped away.

Besides serving to dress cuts or scratches, the plastic is put on prior to surgery. Following the operation, the edges are sewn together with fine stainless-steel wire, forming a sterile covering that permits physicians to observe the incision as though through a window. In a few days the stitches are removed and the layer is peeled off. Small quantities of the material are spread on with a spatula, but in the case of areas of considerable size, it is sprayed on with an air gun.

Bonoplast was developed by chemists of the Swedish Bofors Armament Works by modifying plastics the firm supplies for use in lacquers. They worked for two years to give the film the desired porosity and also to impart the necessary adhesiveness to the liquid so it would stick to the skin. A similar product is now being made in England.

* * *

Did You Know?

An air slugger isn't a bludgeon. It's just a name coined on a job to designate the method that helped place some concrete where it was wanted. In lining the steel-supported arch section of the Gaviota Gorge Tunnel of the California highway system, it was necessary because of restricted headroom to divide the delivery end of the line carrying concrete from a Pumpcrete machine. In order to direct the discharging material as desired and to push it away from the ends of the pipes and into the furthermost recesses of the form, three compressed-air connections were made. One was about 2 feet back of the line's branching point and the others were in the wye, one in each leg. The name air slugger was given this aid by John E. Witte, resident engineer, who described the project in the May-June issue of *California Highways and Public Works.*

* * *

Salvage from Storm

Here is another instance of an ill wind blowing good. In the forests of northeastern Scotland a storm toppled an estimated 40 million cubic feet of timber, but approximately one-third of the wood can be used for pit props and other purposes in the coal mines of the British Isles. As a result, less timber will have to be imported during the next two years. The National Coal Board has arranged to send men and machinery into the affected area to help harvest the windfall.

* * *

Oak Ridge Ceramics Research

Finding suitable materials for the construction of reactors or atomic furnaces is one of the knotty problems involved in the development of nuclear-power equipment. Reactors operating at temper-

atures exceeding 800°F may prove to be the most economical. Ceramic materials can perhaps withstand great heat better than metals, and they have shown special promise for use in building low-cost "power-package" reactors.

The ceramics department of the Oak Ridge (Tenn.) National Laboratory, which is operated by Union Carbide & Carbon Corporation, is devoting most of its efforts to searching for acceptable heat-resistant materials. Cermets, combinations of ceramics and metals, are under study, and oxide, boride and nitride ceramics are being tried out in structural roles. The goal of another line in the investigations is the development of satisfactory techniques for applying ceramic coatings to materials for reactors. One method, which is illustrated, consists in spraying a finely powdered ceramic with compressed air through a flame and onto the surface to be covered.

* * *

Cobalt's Novel Clan

It came to light last month during the celebration of the fiftieth anniversary of the discovery of mineral at Cobalt in Canada that a unique organization existed there in the early days. It was called the Fifty Centers because its members kept a half-dollar in their pockets at all times to meet such exigencies as buying a final meal before going broke or helping out a fellow miner or prospector who was up against it. The money was never spent unless a real emergency arose. Old-timers revived the society for the period of the festivities and initiated various prominent visitors into the camp by requiring each one of them to toss a half-dollar into a pot.

* * *

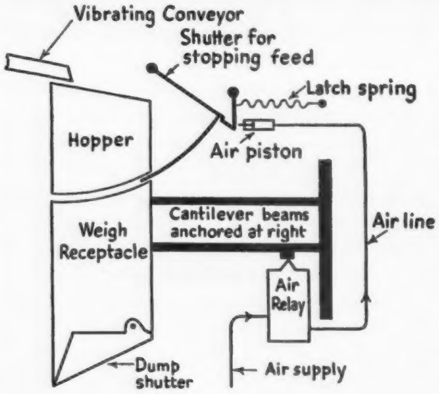
Continuous Concrete Mixing

A German firm is manufacturing a concrete mixer that functions continuously, in contrast to the intermittent action of conventional equipment. Mixing is done by a screw that turns in an elongated chamber, which is inclined at an angle of 22° from the feed end so that the materials tend to fall back for additional mixing during their upward progress. Batching of cement and aggregates from four hoppers, which can be filled by hand or conveyor belts, is automatic. Water is introduced through a hose line at a constant rate maintained by regulating the tap. The machine is 9 feet long, 5 feet high and 43 inches wide, weighs 1500 pounds and is mounted on a pair of wheels. It can be run by either a gasoline engine or electric motor and operates at two speeds, one of which turns out $6\frac{1}{2}$ cubic yards per hour and the other $10\frac{1}{2}$ cubic yards.

Air Controls Overweight in Packaging

IF EACH seven-ounce package of breakfast food put up by General Mills averaged ⅛ ounce overweight, the annual loss would amount to $100,000 at the present rate of production. It therefore behooves the corporation to make sure that the filling equipment used is as accurate as it is possible to make it, for any unit reduction, no matter how small, means an appreciable saving. To this end the company installed a new type of weighing machine at its Buffalo, N.Y., plant a little more than a year ago and recently added another. Of the straight-line multihead type, it has lowered the average overfill in the case of Wheaties to a fraction of ⅛ ounce, the specific weight tolerance obtainable depending upon the nature of the product.

The scale mechanism, known as the Pneumatron, works on the same principle as air-operated automatic control instruments and is shown in simplified form in the accompanying diagram. The cereal to be packaged is fed by the vibrating conveyor into the hopper, from which it flows into the weigh receptacle. As it does so, the cantilever beam is deflected downward, narrowing by a few thousandths of an inch the gap between a flat plate and a tiny jet that directs a minute stream of compressed air against it. Restriction of the space increases the pressure in the air line leading to the nozzle and causes the relay to admit air to the latch-spring piston. This closes the feed shutter and thus stops the flow from the hopper into the weigh receptacle. Its contents are then dumped by way of a funnel into the package spotted beneath it, the shutter is again opened and the cycle is repeated. When lined boxes are filled, the lining is spread by means of a suction hood attached to the bottom of the funnel.



SINGLE-FEED SCALE MECHANISM

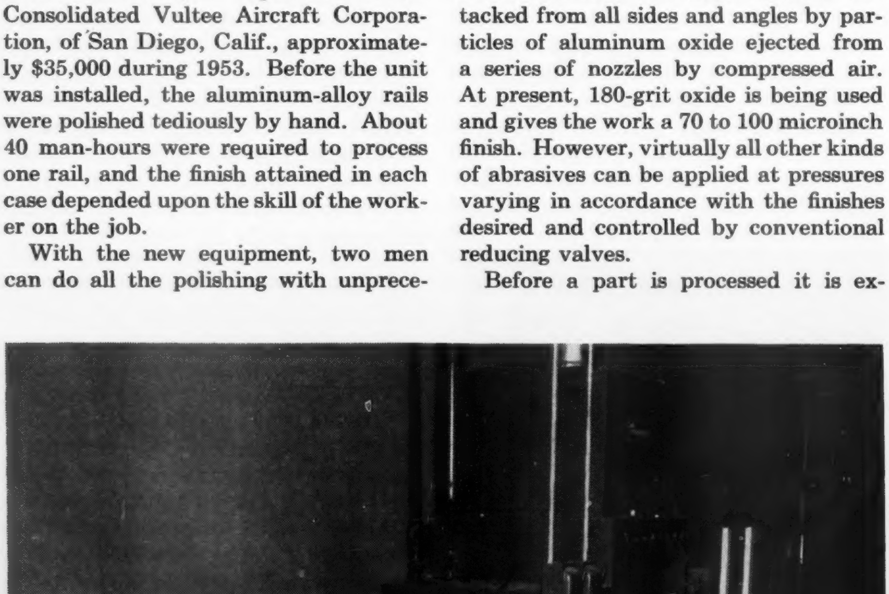
For products that present a weighing problem, there are twin-scale mechanisms. In this case each hopper has two shutters at the outlet end, one for feeding a large stream and the other a small one. The big one closes when the weight of the material is nearly equal to that of the full contents of the carton, leaving the little one to finish packaging in driblets until the specified weight is reached. A 4-scale dual-weighing machine running at top speed is said to fill 90 boxes a minute with precision and a single-weighing 4-scale Pneumatron 140 cartons a minute.

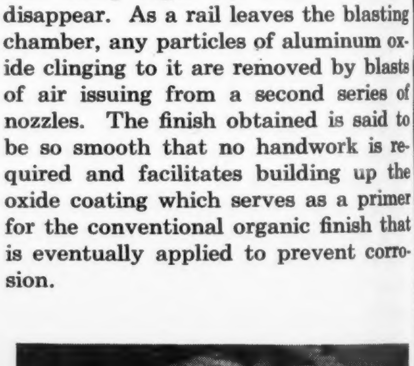
Grit-blasting Machine Gives Satin Finish

A NEW type of sandlbasting machine, which gives a satin finish to the 40-foot spar rails used in the wings of modern airliners, is expected to save Consolidated Vultee Aircraft Corporation, of San Diego, Calif., approximately $35,000 during 1953. Before the unit was installed, the aluminum-alloy rails were polished tediously by hand. About 40 man-hours were required to process one rail, and the finish attained in each case depended upon the skill of the worker on the job.

With the new equipment, two men can do all the polishing with unprecedented speed and uniformity. A conveyor belt feeds the metal rails at the rate of 10 feet per minute through a boxlike chamber in which each is attacked from all sides and angles by particles of aluminum oxide ejected from a series of nozzles by compressed air. At present, 180-grit oxide is being used and gives the work a 70 to 100 microinch finish. However, virtually all other kinds of abrasives can be applied at pressures varying in accordance with the finishes desired and controlled by conventional reducing valves.

Before a part is processed it is examined for scratches or gouges. If deep, they are smoothed out; if slight, the peening action of the grit wears away their sharp edges and causes them to disappear. As a rail leaves the blasting chamber, any particles of aluminum oxide clinging to it are removed by blasts of air issuing from a second series of nozzles. The finish obtained is said to be so smooth that no handwork is required and facilitates building up the oxide coating which serves as a primer for the conventional organic finish that is eventually applied to prevent corrosion.

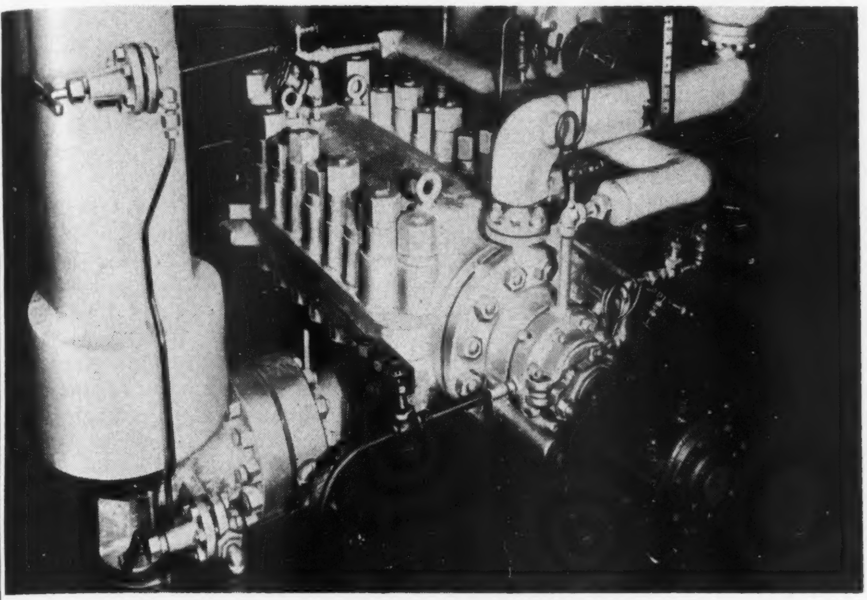




MACHINE AND ITS NOZZLES

General view of the Pangborn enclosed blasting unit with a spar rail emerging after it has been cleaned and polished. Above is a picture inside the cabinet showing the intricate radial assembly of hoses and nozzles surrounding a rail section in position for surface finishing.

Boiler Feed Pump Has Run 100,000 Hours



MARATHON RUNNER
This boiler feed pump has not been opened since it went into service in 1938 and is still operating regularly. It delivers 1000 gpm of 380°F water at 1900 psi pressure.

MANAGER R.F. Kellogg of the Beech Bottom Power Company's Windsor station at Power, W.Va., recently reported that an Ingersoll-Rand high-pressure boiler feed pump had successfully passed its 100,000th hour of operation without having been opened for inspection or repair. This outstanding service record has been compiled in the fifteen years since the unit was installed during an expansion program that increased the plant's capacity to 240,000 kw. To put the performance in terms more understandable to the layman, engineers have likened it to that of an automobile circling the earth 160 times at 40 miles per hour without an engine overhaul.

Many pump manufacturers advocate letting a boiler feed pump alone so long as it is operating satisfactorily, but recommend keeping a weather eye on instruments and controls that indicate loss in head or capacity rating or an increase in power consumption. These are symptoms of internal wear, and their extent is a good index of the immediacy of the repairs a machine may require.

Maintenance of the 7-stage horizontally split pump, designated as Class HT by its manufacturer, has been limited to infrequent repacking even though the unit operates under 415 psi suction pressure and at 380°F. temperature. The axial thrust of its 9-foot-long rotor, with in-line arrangement of its stages, is neutralized at the high-pressure end by a balancing drum, which also breaks down the 1900-psi discharge pressure to suction pressure. Despite the differential of nearly 1500 psi none of the parts of the breakdown has had to be renewed.

Behind the pump's impressive performance lie years of metallurgical research carried out by the manufacturer in an effort to develop materials best suited for boiler feed service, which is admittedly severe. But even with all this and a high order of workmanship, the machine could not have performed as it has without the power plant's careful operation and feed-water control.

Though overshadowed by their counterpart, five other HT boiler feed pumps in the Windsor station have had similar successful maintenance records. Four of them, installed at a later date, have each piled up from 50,000 to 80,000 unopened hours of service. The other one, which was set up at the same time as the 100,000-hour unit, was opened for inspection a few years ago—unnecessarily, as it developed, because there was no need of repairs. It was put back in service unaltered. It may be that that has had something to do with setting the performance record, which is a credit to both the maker and the Windsor station.

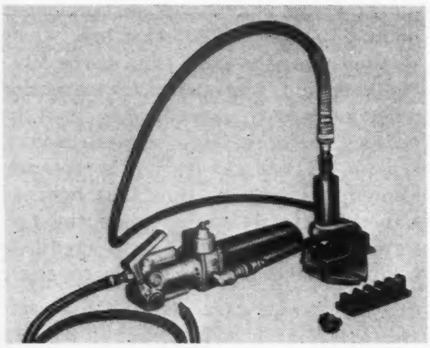
Mill Saws Chilled Wood

PUTTING lumber in a cooler sounds like borrowing trouble, but that is actually done by the Birds-Eye Veneer Company at Escanaba, Mich., to avoid trouble. The concern handles basswood which, apparently, cuts smoothly only in cold weather. Formerly the mill had to shut down during the hot season because the edges of the thin sheets of veneer were rough and uneven. All sorts of cutting and processing methods were tried without success until the concern conceived the idea of chilling the lumber.

The refrigeration unit built is 20 feet long, 15 feet wide and 12 feet high and is closed at one end by an upward-swinging door through which a loaded carrier can pass freely. The installation consists of a 3-hp compressor outside the room and three forced-air cooling units suspended from the ceiling. When first tested, it reduced the temperature of 5000 board feet from a maximum of 90° to 48°F in 24 hours, and now regularly maintains the lumber at just below 40°, at which it is in the best condition for cutting.

AMERICAN MACHINES ABROAD
This street scene in Tel-Aviv, Israel, looks much like one at home. It shows employees of the Tel-Aviv Municipal Corporation making ready to resurface a street. Some of the men at the right are wielding picks, while two others are operating paving breakers. Air for running the tools comes from an Ingersoll-Rand 210-cfm Gyro-Flo compressor (left) that has been in steady service for a year without requiring attention other than routine maintenance and fueling.

Industrial Notes



For the purpose of applying terminals as well as splices on No. 8 to 4/0 aircraft cable, Burndy Engineering Company, Inc., is offering a new rack-type Hypress that is said to exert an indenting force of 9000 psi with air at 60 psi, line pressure. The tool consists of an air-hydraulic pump and of a hydraulic cylinder and ram mounted in a frame together with a sliding rack with standard nest contours. The work can be fed either from the side or the front, and a spring-loaded pull button on the frame accurately spots the rack under the indentor. Standard indentors are used, but they are permanently fixed in special adaptors that shoulder against the rack. This insures control of the depth of the indentation and enables the operator to see when the work is completed.

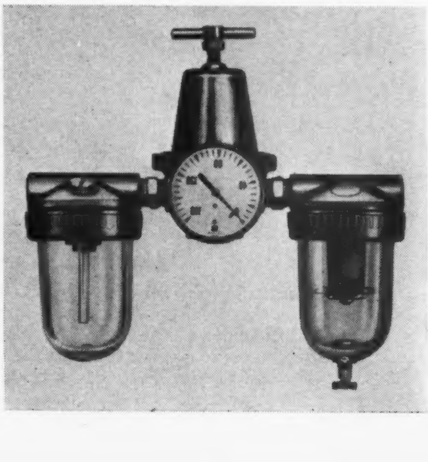
Corrugated plywood is being produced on a commercial scale for industrial and construction purposes by presses invented by a Brazilian engineer. Interposed between the platens of the new machine are several wave sections that are separated from them by springs. These are longest at the center so that when the press is closed the plies are brought in contact with the molds progressively from the center outward. Pressure and heat are applied after the corrugations are formed. They are said to be permanent. The material is now being tested in the United States. According to reports from the Brazilian Technological Research Institute of Sao Paulo, sheets 30x80 inches in size withstand a pressure of more than a ton. The veneer weighs less than a pound a square foot and has been used to build houses with roofs supported by the walls without the use of vertical wooden studs. At present, its principal application in Brazil is as a roofing material.

A clutch equilibrator is now standard equipment on all Diamond Multi-Max punch presses and shears, according to an announcement by Diamond Machine Tool Company. The device consists of two parts—a heart-shaped cam and an air chamber with an automatic pumping and regulating mechanism—and serves to counterbalance the punch and die plates that vary from one setup to another. It is also said to act as a frictionless brake and to take the load from the clutch assembly at the time of disengagement.

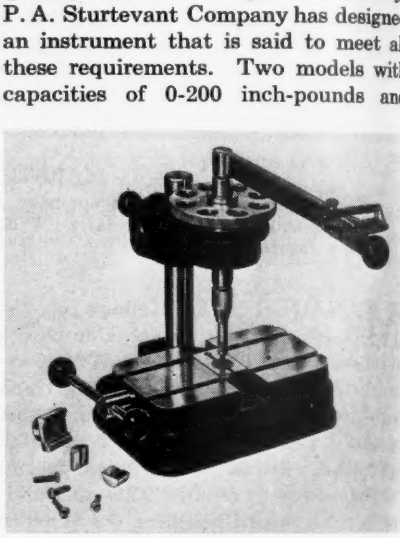
Powered by a gas turbine, a 27-ton truck-trailer recently made a run along the Pacific Coast from Canada to Mexico in 60 hours. The revolutionary prime mover weighs only 200 pounds, or 3000 pounds less than the diesel engine originally installed in the vehicle.

It is reported that The International Nickel Company advanced the underground workings of its productive mines in the Sudbury District of northern Ontario, Canada, about 25 miles in 1952, giving them a total length of 325 miles!

Arrow Tools, Inc., has announced a new filter-regulator-lubricator that is said to embody a number of distinctive features. Air entering the filter is subjected to centrifugal action which throws some of the entrained moisture and solids against the walls and down into the bottom of the transparent bowl from which the deposit can be withdrawn through a drain cock. Housed in the filter is a porous bronze element with a baffle at the lower end. The latter creates a relatively quiet zone from which the air flows up and through the bronze element which, it is claimed, removes even the finest particles remaining and holds a greater than normal amount of foreign matter without a serious loss in pressure. The element can be taken out for cleaning. This is done by blowing compressed air into it to dislodge the material clinging to the outer surface. The lubricator has a porous bronze feeder wick that forces the oil into the air stream in a fine mist, the quantity delivered ordinarily varying automatically with the flow. If not, the elevation of the wick can be changed to feed more or less oil, as desired. Improvements incorporated in the regulator include: a positive-action self-bleeder to prevent pressure build-up in dead-end applications and a diaphragm of a new oil-resistant material reinforced with nylon cord. Units of the assembly may be used singly or in combination with or without the regulator.



Because of the demand for a universal fixture that would make it possible to determine the ultimate strength of screws or threaded connections and to apply proof loads; to test materials and parts where torsional strength is an ultimate factor; and to prevent breakage by accurately controlling torque applied in driving nuts, screws or other parts requiring controlled torque in assembly, P. A. Sturtevant Company has designed an instrument that is said to meet all these requirements. Two models with capacities of 0-200 inch-pounds and 0-150 foot-pounds are now in production and are operated by a torque wrench through an adjustable spindle with a female drive square that allows a wide choice in wrenches within the limits of each fixture. The latter includes a standard male drive-square attachment that is fitted to the threaded driving end of the spindle and permits the use of regular sockets, socket screw drivers, etc., without alterations. The model illustrated shows a screw undergoing test to determine its ultimate strength—a typical application.

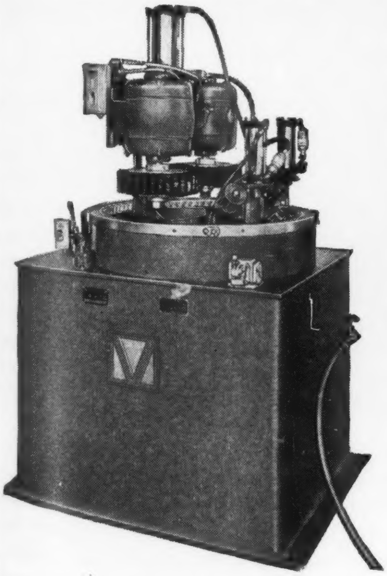


Turbine discharge pressure on jet engines is being controlled by a tiny pneumatic device developed by the Solar Aircraft Company. Known as Microjet, it is said to compute automatically what the discharge pressure should be under all flight conditions. When there is a discrepancy between the actual and the ideal pressure, it causes electric signals to flash the fact to other engine controls which adjust the pressure.

Under the trade name Commander, The B. F. Goodrich Company is offering a new heavy-duty air hose for mine and quarry service, construction projects and general industrial use where pressures

up to 400 psi may be required. The hose is reinforced with a single braid of high-tensile steel wire and is oil resistant both outside and inside so lubricant can be fed through it to the tools. It has a light-gray cover for increased visibility underground and is made in ½-, ¾- and 1-inch sizes.

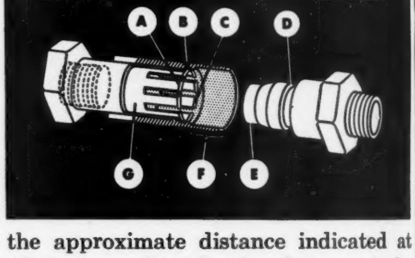
Jet-engine stator rings, half rings or circular workpieces made up of more parts can be deburred on a high production basis, it is claimed, by use of a new turntable-type machine developed by Grinding & Polishing Machinery Corporation. Rings or sectional rings varying in diameter are individually clamped by interchangeable 3-jaw holding fixtures to a master ring rotated by a ½-hp motor through a constant-speed spur gear. As the table turns, six wheel-shaped wire brushes are brought into action. These operate in sets of two running in opposite directions and are brought in contact with the work by pneumatic cylinders using air at 90 psi. Two large polishing-head units are mounted on vertical spindles driven by 1-hp motors and remove the burr from those parts of the broached slots that are on the flat inside diameter of the ring. The sections where the slots break through the side wall of the channels at the edges of the ring are deburred by two pairs of small wire brushes operated by two pairs of angularly mounted air motors. One set finishes the top edge and



EXPEDITES DEBURRING
The new turntable deburring machine with two half rings locked to the master ring and with brushes raised. Only two pairs are shown: the large brush-head assembly, which is positioned by the pneumatic cylinder above it, and, right, the top pair of smaller wire brushes which, together with their air motors, are lowered and lifted by the left-hand cylinder. The outer one controls the bottom pair. The master ring makes 12 rpm. By using variable- instead of constant-speed drive it can be rotated 5.5 to 55 times a minute.

the other the bottom edge. The motors are reversible so that the brushes can be reversed to prevent the bristles from becoming set. All control equipment such as push buttons for the electric motors, valves for the pneumatic cylinders and for changing the direction of the air motors, and the clutch lever are mounted on the machine's fabricated steel base. According to the records of one user, 32-inch aluminum half rings were loaded, deburred and unloaded at the rate of two a minute—a complete time cycle. By previous hand methods it took eight hours to finish a set of 24 half rings.

A quick coupling based on a new principle and developed by Corley Sales & Engineering Company for use in the aircraft industry is now being offered for general application. With ends adaptable for any standard connection, it is suitable for linking flexible cable, tubing, hose or piping carrying liquids or gases under varying pressures; for hooking tractors to trailers and agricultural implements; and, with an integral ball and socket, for joining control rods. Coupling is effected by moving the sleeve back



the approximate distance indicated at "F," thus allowing the fingers of the collet to expand slightly. The male section is then inserted and the sleeve pushed forward, causing shoulder "C" to engage shoulder "D" and ribs "A" to seat in slot "B," securely locking the coupling. To break it, the procedure is reversed. Normally, a simple type of seal is used where "E" engages "G," but for service where pressure is involved it is designed to meet requirements. Standard checks can be incorporated where shutoff is essential.

Finely ground cellulose is available under the name of Cottontex for use as a degreasing and drying material in tumbling mills. It is said to absorb more than eight times its weight in oil, grease or other liquid and, because of its softness, to protect parts such as bearings during the processing operation.

Construction and lumbermen, survey parties, hunters, campers and others that venture into snake-infested country can safeguard themselves against poisonous bites by wearing trousers of heavy canvas with a detachable lining woven of fine Monel-metal wire. Designed by the Gokey Company, the garment is said to provide thigh-high protection.

Industrial Literature

American Brake Shoe Company has issued a 12-page booklet on the properties, characteristics and applications of its three standard grades of Ductalloy (trade name for its ductile iron). Typical castings for use in aviation and chemical, diesel and general industrial fields are pictured. Write the company to Dept. A, 230 Park Avenue, New York 17, N.Y., for a copy.

Bulletin UA-530 recently released by the American Brass Company describes its "Sealtite," a flexible liquid-tight conduit for electrical wiring that is said to be the first of its kind to win the approval of Underwriters' Laboratories for service in wet locations. Copy may be obtained by addressing the company's American Metal Hose Branch, 692 Main Street, Waterbury, Conn.

Aluminum in Materials Handling is the title of a 20-page illustrated booklet containing reprints of six articles covering the results of a survey made by The Aluminum Association of more than 50 manufacturers and users of equipment of this type. The publication can be obtained from the Association, 420 Lexington Avenue, New York 17, N.Y., by writing request on company letterhead.

A new bulletin, F 5783, issued by Wheelco Instruments Division, Barber-Colman Company, Rockford, Ill., deals with its Model 200 Series Capacitrols—direct reading on-off, proportioning and anticipating temperature controllers. Included is a description of its new Capaciline or "straight-line" Models 221C and 224C, units that anticipate the approach or departure of temperature from the control point.

Bailey Meter Company, 1050 Ivanhoe Road, Cleveland 10, Ohio, has released a catalogue—No. 18—giving information on its complete line of control equipment, meters and engineering services. Written for engineers in public-utility, power and process plants, it lists fifteen measured variables that are common to such plants and form the index for the selection of appropriate metering and control equipment.

A recent Circular, No. 558, prepared for free distribution by The Lunkenheimer Company, Box 360-U, Cincinnati 14, Ohio, describes the functions of its nonmetallic disk valves and lists those that can be renewed or converted for other services by the insertion of any one of three types of special disks designed for use with saturated steam; cold water, air or gas; and gasoline, oil, butane or propane.

Heli-Coil Corporation has announced the availability of a completely revised catalogue on its Heli-Coil or wire screw-thread inserts. Of 22 pages and spiral-bound for convenience, it introduces new specifications for inserts covering Class 2, 2B, 3 and 3B fits and explains their uses by aid of photographs and drawings. Requests for Catalogue No. 652 should be addressed to the corporation at 1360 Shelter Rock Lane, Danbury, Conn.

Pelron Corporation, 7700 W. 47th Street, Lyons, Ill., has announced a new brochure dealing with the services it is equipped to render the finishing industry. The company makes studies of special problems relating to metal cleaning, phosphating, paint stripping and paint-booth operations and recommends and develops compounds to meet specific needs. Also included is a description of its standard products for finishing metals.

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